

## **ATTACHMENT D**

### **Estimates of Carcinogenic and Noncarcinogenic Risk – RME Scenario**

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**Attachment D**

**Summary of Chemicals of Potential Concern and Exposure Point Concentrations by Receptor and Media  
Reasonable Maximum Exposure**

Chemical	Commercial/Industrial				Recreational					
	Residential		General Industrial Worker		Maintenance Worker	Construction Worker	Recreational User	Swimmer/Wader		Fisherman
	Surface and Subsurface	Indoor Air	Surface Soil	Indoor Air <sup>(a)</sup>	Surface Soil	Surface and Subsurface	Surface Soil	Sediment	Surface Water	Fish Tissue
<b>Inorganics</b>										
Antimony	-	-	-	-	-	-	-	3.73	-	-
Arsenic	5.07	-	3.65	-	4.81	4.90	5.27	-	-	-
Cadmium	-	-	-	-	-	-	1.26	-	-	-
Iron	-	-	-	-	-	-	-	20,077	-	-
Lead	90.48	-	-	-	99.31	88.74	103	-	-	-
Manganese	-	-	-	-	-	-	-	190	-	-
Thallium	0.82	-	-	-	-	-	1.02	-	-	-
Vanadium	-	-	-	-	-	-	-	26.72	-	-
<b>SVOCs</b>										
1-Methylnaphthalene	150	-	-	-	-	1,314	-	11.91	-	0.62
2-Methylnaphthalene	144	-	-	-	-	1,412	-	24.37	-	-
Acenaphthene	36.42	-	-	-	-	441	-	-	-	-
Benz(a)anthracene	24.59	-	-	-	2.67	197	3.44	9.31	-	0.170
Benz(a)pyrene	19.51	-	0.18	-	5.23	172.82	6.37	9.14	-	0.019
Benz(e)pyrene	-	-	-	-	-	-	-	-	-	0.010
Benz(b)fluoranthene	21.28	-	-	-	4.90	102	6.41	5.56	-	0.015
Benz(k)fluoranthene	10.12	-	-	-	-	119	1.80	5.58	-	-
Chrysene	23.38	-	-	-	-	181	-	-	-	-
Dibenz(a,h)anthracene	3.12	-	-	-	-	26.19	-	-	-	0.0076
Dibenzofuran	9.93	-	-	-	-	89.23	-	-	-	0.0026
Fluoranthene	63.62	-	-	-	-	329	-	-	-	-
Fluorene	45.88	-	-	-	-	282	-	-	-	-
Indeno(1,2,3-cd)pyrene	5.34	-	-	-	3.30	93.43	4.29	4.79	-	-
Naphthalene	188	-	-	-	-	1,173	-	26.68	-	-
Phenanthrene	144	-	-	-	-	-	-	-	-	-
Pyrene	85.60	-	-	-	-	485	-	-	-	-
<b>VOCs</b>										
1,2,4-Trichlorobenzene	29.62	-	-	-	-	181	-	-	-	-
1,2,4-Trimethylbenzene	6.06	-	-	38.76	-	3.56	-	-	-	-
1,3,5-Trimethylbenzene	15.74	-	-	9.32	-	17.06	-	-	-	-
1,4-Dichlorobenzene	-	-	-	961.57	-	-	-	-	-	-
Benzene	14.29	-	-	38.32	-	14.30	-	-	-	-
Ethylbenzene	-	-	-	-	-	44.35	-	-	-	-
n-Butyl benzene	-	-	-	-	-	39.87	-	-	-	-
sec-Butyl benzene	-	-	-	-	-	43.35	-	-	-	-
Carbon tetrachloride	-	-	-	10.70	-	-	-	-	-	-
Methylene Chloride	-	-	-	4.86	-	-	-	-	-	-
Toluene	-	-	-	-	-	29.55	-	-	-	-
Trichloroethylene	-	-	-	3.16	-	-	-	-	-	-
Xylenes (total)	52.19	-	-	-	-	187	-	-	-	-

Notes:

All units are in milligram/kilogram (mg/kg)

a - Maximum concentrations were used due to lack sufficient data for statistical analysis.

## Attachment D

**Table 1a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Residential Adult and Child: Incidental Ingestion of Soil Pathway (0-10 feet) – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Csoil} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{SIRadj} \times \text{FI})}{\text{ATc}}$$

Equation Units	Ing - Risk unitless	Csoil mg/kg	SFo kg-day/mg	CF kg/mg	EF days/year	SIRadj mg-yr/kg-day	FI unitless	) ÷ (	ATc days
Arsenic	1.19E-05	= ( 5.07E+00 × 1.50E+00 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Lead	NA	= ( 9.05E+01 × a × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Thallium	NA	= ( 8.17E-01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
1-Methylnaphthalene	NA	= ( 1.50E+02 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
2-Methylnaphthalene	NA	= ( 1.44E+02 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Acenaphthene	NA	= ( 3.64E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Benzo(a)anthracene	2.81E-05	= ( 2.46E+01 × 7.30E-01 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Benzo(a)pyrene	2.23E-04	= ( 1.95E+01 × 7.30E+00 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Benzo(b)fluoranthene	2.43E-05	= ( 2.13E+01 × 7.30E-01 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Benzo(k)fluoranthene	1.16E-06	= ( 1.01E+01 × 7.30E-02 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Chrysene	2.67E-07	= ( 2.34E+01 × 7.30E-03 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Dibenz(a,h)anthracene	3.56E-05	= ( 3.12E+00 × 7.30E+00 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Dibenzofuran	NA	= ( 9.93E+00 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Fluoranthene	NA	= ( 6.36E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Fluorene	NA	= ( 4.59E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Indeno(1,2,3-cd)pyrene	6.11E-06	= ( 5.34E+00 × 7.30E-01 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Naphthalene	NA	= ( 1.86E+02 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Phenanthrene	NA	= ( 1.44E+02 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Pyrene	NA	= ( 8.56E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
1,2,4-Trichlorobenzene	NA	= ( 2.96E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
1,2,4-Trimethylbenzene	NA	= ( 6.06E+00 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
1,3,5-Trimethylbenzene	NA	= ( 1.57E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Benzene	1.23E-06	= ( 1.43E+01 × 5.50E-02 × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							
Xylenes (total)	NA	= ( 5.22E+01 × NV × 1E-06 × 350 × 114.28 × 1 ) ÷ ( 25,550 )							

**Notes:**

Ing - Risk – Ingestion risk

Csoil – Soil Concentration

SFo – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SIRadj – Age-adjusted Soil Ingestion Rate

FI – Fraction Ingested from Contaminated Source

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 1b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Residential Child: Incidental Ingestion of Soil Pathway (0-10 feet) – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{EDc} \times \text{SIRc} \times \text{FI})}{(\text{BWc} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	EDc years	×	SIRc mg/day	×	FI unitless	) ÷ (	BWc kg	×	ATn days	×	RfDo <sup>(b)</sup> mg/kg-day
Arsenic	2.16E-01	= (	5.07E+00	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	3.0E-04 )
Lead	NA	= (	9.05E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	a )
Thallium	1.31E-02	= (	8.17E-01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	8.0E-04 )
1-Methylnaphthalene	2.74E-02	= (	1.50E+02	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	7.0E-02 )
2-Methylnaphthalene	4.60E-01	= (	1.44E+02	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	4.0E-03 )
Acenaphthene	7.76E-04	= (	3.64E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	6.0E-01 )
Benzo(a)anthracene	NA	= (	2.46E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Benzo(a)pyrene	NA	= (	1.95E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Benzo(b)fluoranthene	NA	= (	2.13E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Benzo(k)fluoranthene	NA	= (	1.01E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Chrysene	NA	= (	2.34E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Dibenz(a,h)anthracene	NA	= (	3.12E+00	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Dibenzofuran	6.35E-02	= (	9.93E+00	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	2.0E-03 )
Fluoranthene	2.03E-03	= (	6.36E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	4.0E-01 )
Fluorene	1.47E-03	= (	4.59E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	4.0E-01 )
Indeno(1,2,3-cd)pyrene	NA	= (	5.34E+00	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Naphthalene	1.19E-01	= (	1.86E+02	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	2.0E-02 )
Phenanthrene	NA	= (	1.44E+02	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	NV )
Pyrene	3.65E-03	= (	8.56E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	3.0E-01 )
1,2,4-Trichlorobenzene	3.79E-02	= (	2.96E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	1.0E-02 )
1,2,4-Trimethylbenzene	1.55E-03	= (	6.06E+00	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	5.0E-02 )
1,3,5-Trimethylbenzene	4.02E-04	= (	1.57E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	5.0E-01 )
Benzene	4.57E-02	= (	1.43E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	4.0E-03 )
Xylenes (total)	1.87E-03	= (	5.22E+01	×	1E-06	×	350	×	6	×	200	×	1	) ÷ (	15	×	2,190	×	3.6E-01 )

**Notes:**

Ing - HQ – Ingestion Hazard

Csoil – Soil Concentration

CF – Unit Conversion Factor

EF – Exposure Frequency

EDc – Exposure Duration, child

SIRc – Soil Ingestion Rate, child

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

FI – Fraction Ingested from Contaminated Source

BWc – Body Weight, child

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 2a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Residential Adult and Child: Dermal Contact with Soil Pathway (0-10 feet) – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csoil} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{EV} \times \text{SCRadj} \times \text{ABSD})}{\text{ATc}}$$

Equation Units	Derm - Risk unitless	Csoil mg/kg	SFabs kg-day/mg	CF kg/mg	EF days/year	EV events/day	SCRadj mg-yr/kg-event	ABSD unitless	) ÷ ( ATc days
Arsenic	1.18E-06	= ( 5.07E+00 × 1.58E+00 × 1E-06 × 350 × 1 × 360 × 3.00E-02 ) ÷ ( 25,550 )							
Lead	NA	= ( 9.05E+01 × a × 1E-06 × 350 × 1 × 360 × NA ) ÷ ( 25,550 )							
Thallium	NA	= ( 8.17E-01 × NV × 1E-06 × 350 × 1 × 360 × NA ) ÷ ( 25,550 )							
1-Methylnaphthalene	NA	= ( 1.50E+02 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
2-Methylnaphthalene	NA	= ( 1.44E+02 × NV × 1E-06 × 350 × 1 × 360 × 1.00E-01 ) ÷ ( 25,550 )							
Acenaphthene	NA	= ( 3.64E+01 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Benzo(a)anthracene	1.15E-05	= ( 2.46E+01 × 7.30E-01 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Benzo(a)pyrene	9.14E-05	= ( 1.95E+01 × 7.30E+00 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Benzo(b)fluoranthene	9.97E-06	= ( 2.13E+01 × 7.30E-01 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Benzo(k)fluoranthene	4.74E-07	= ( 1.01E+01 × 7.30E-02 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Chrysene	1.10E-07	= ( 2.34E+01 × 7.30E-03 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Dibenz(a,h)anthracene	1.46E-05	= ( 3.12E+00 × 7.30E+00 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Dibenzofuran	NA	= ( 9.93E+00 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Fluoranthene	NA	= ( 6.36E+01 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Fluorene	NA	= ( 4.59E+01 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Indeno(1,2,3-cd)pyrene	2.50E-06	= ( 5.34E+00 × 7.30E-01 × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Naphthalene	NA	= ( 1.86E+02 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Phenanthrene	NA	= ( 1.44E+02 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
Pyrene	NA	= ( 8.56E+01 × NV × 1E-06 × 350 × 1 × 360 × 1.30E-01 ) ÷ ( 25,550 )							
1,2,4-Trichlorobenzene	NA	= ( 2.96E+01 × NV × 1E-06 × 350 × 1 × 360 × NV ) ÷ ( 25,550 )							
1,2,4-Trimethylbenzene	NA	= ( 6.06E+00 × NV × 1E-06 × 350 × 1 × 360 × NA ) ÷ ( 25,550 )							
1,3,5-Trimethylbenzene	NA	= ( 1.57E+01 × NV × 1E-06 × 350 × 1 × 360 × NA ) ÷ ( 25,550 )							
Benzene	NA	= ( 1.43E+01 × 5.50E-02 × 1E-06 × 350 × 1 × 360 × NA ) ÷ ( 25,550 )							
Xylenes (total)	NA	= ( 5.22E+01 × NV × 1E-06 × 350 × 1 × 360 × NA ) ÷ ( 25,550 )							

**Notes:**

Derm - Risk – Dermal Risk

Csoil – Soil Concentration

SFabs – Absorbed slope factor ( $\text{SFo} \div \text{ABSGi}$ )

CF – Unit Conversion Factor

EF – Exposure Frequency

EV – Event Frequency

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SCRadj – Age-adjusted Soil Contact Rate

ABSD – Dermal Soil Absorption Factor

ATc – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

## Attachment D

**Table 2b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Residential Child: Dermal Contact with Soil Pathway (0-10 feet) – Noncarcinogenic Effects**

Derm - HQ = 
$$\frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{EDc} \times \text{EV} \times \text{SAc} \times \text{AFc} \times \text{ABSd})}{(\text{BWc} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	EDc years	×	EV events/day	×	SAc cm <sup>2</sup>	×	AFc mg/cm <sup>2</sup> -event	×	ABSd unitless	) ÷ (	BWc kg	×	ATn days	×	RfDabs <sup>(b)</sup> mg/kg-day
Arsenic	1.91E-02	= (	5.07E+00	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	3.00E-02	) ÷ (	15	×	2,190	×	2.85E-04 )
Lead	NA	= (	9.05E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	a )
Thallium	NA	= (	8.17E-01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	8.00E-04 )
1-Methylnaphthalene	9.98E-03	= (	1.50E+02	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	7.00E-02 )
2-Methylnaphthalene	1.29E-01	= (	1.44E+02	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.00E-01	) ÷ (	15	×	2,190	×	4.00E-03 )
Acenaphthene	2.82E-04	= (	3.64E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	6.00E-01 )
Benzo(a)anthracene	NA	= (	2.46E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Benzo(a)pyrene	NA	= (	1.95E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Benzo(b)fluoranthene	NA	= (	2.13E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Benzo(k)fluoranthene	NA	= (	1.01E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Chrysene	NA	= (	2.34E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Dibenzo(a,h)anthracene	NA	= (	3.12E+00	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Dibenzofuran	2.31E-02	= (	9.93E+00	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	2.00E-03 )
Fluoranthene	7.40E-04	= (	6.36E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	4.00E-01 )
Fluorene	5.34E-04	= (	4.59E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	4.00E-01 )
Indeno(1,2,3-cd)pyrene	NA	= (	5.34E+00	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Naphthalene	4.33E-02	= (	1.86E+02	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	2.00E-02 )
Phenanthrene	NA	= (	1.44E+02	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV )
Pyrene	1.33E-03	= (	8.56E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	3.00E-01 )
1,2,4-Trichlorobenzene	NA	= (	2.96E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NV	) ÷ (	15	×	2,190	×	NV )
1,2,4-Trimethylbenzene	NA	= (	6.06E+00	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	5.00E-02 )
1,3,5-Trimethylbenzene	NA	= (	1.57E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	5.00E-01 )
Benzene	NA	= (	1.43E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	4.00E-03 )
Xylenes (total)	NA	= (	5.22E+01	×	1E-06	×	350	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	3.57E-01 )

**Notes:**

Derm - HQ – Dermal Hazard Quotient

AFc – Soil-to-skin Adherence Factor, child

Csoil – Soil Concentration

ABSd – Dermal Soil Absorption Factor

CF – Unit Conversion Factor

BWc – Body Weight, child

EF – Exposure Frequency

ATn – Averaging Time for noncarcinogens

EDc – Exposure Duration, child

RfDabs – Absorbed reference dose (RfDo × ABSgi)

EV – Event Frequency

NA – Not Applicable

SAc – Skin Surface Area, child

NV – No toxicity value available for this pathway.

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

## Attachment D

**Table 3a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Residential Adult and Child: Inhalation of Soil-derived Chemicals Pathway (0-10 feet)– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFi} \times \text{EF} \times \text{SinhRadj} \times [(1/\text{VF}) + (1/\text{PEF})])}{\text{ATc}}$$

Equation Units	Inh - Risk unitless	Csoil mg/kg	SFi kg-day/mg	EF days/year	SinhRadj m <sup>3</sup> -yr/kg-day	VF <sub>adult</sub> m <sup>3</sup> /kg	+ 1 /	PEF m <sup>3</sup> /kg	] ) ÷ ( ATc ) days
Arsenic	1.72E-09	= ( 5.07E+00 × 1.51E+01 × 350 × 10.86 × [ 1 / NA + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Lead	NA	= ( 9.05E+01 × a × 350 × 10.86 × [ 1 / NA + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Thallium	NA	= ( 8.17E-01 × NV × 350 × 10.86 × [ 1 / NA + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
1-Methylnaphthalene	NA	= ( 1.50E+02 × NV × 350 × 10.86 × [ 1 / 3.28E+04 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
2-Methylnaphthalene	NA	= ( 1.44E+02 × NV × 350 × 10.86 × [ 1 / 3.11E+04 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Acenaphthene	NA	= ( 3.64E+01 × NV × 350 × 10.86 × [ 1 / 6.00E+04 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Benzo(a)anthracene	NA	= ( 2.46E+01 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Benzo(a)pyrene	1.36E-09	= ( 1.95E+01 × 3.08E+00 × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Benzo(b)fluoranthene	NA	= ( 2.13E+01 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Benzo(k)fluoranthene	NA	= ( 1.01E+01 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Chrysene	NA	= ( 2.34E+01 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Dibenzo(a,h)anthracene	NA	= ( 3.12E+00 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Dibenzofuran	NA	= ( 9.93E+00 × NV × 350 × 10.86 × [ 1 / 4.98E+04 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Fluoranthene	NA	= ( 6.36E+01 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Fluorene	NA	= ( 4.59E+01 × NV × 350 × 10.86 × [ 1 / 9.16E+04 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Indeno(1,2,3-cd)pyrene	NA	= ( 5.34E+00 × NV × 350 × 10.86 × [ 1 / NC + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Naphthalene	NA	= ( 1.86E+02 × NV × 350 × 10.86 × [ 1 / 2.87E+04 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Phenanthrene	NA	= ( 1.44E+02 × NV × 350 × 10.86 × [ 1 / 1.46E+05 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Pyrene	NA	= ( 8.56E+01 × NV × 350 × 10.86 × [ 1 / 3.05E+05 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
1,2,4-Trichlorobenzene	NA	= ( 2.96E+01 × NV × 350 × 10.86 × [ 1 / 1.44E+05 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
1,2,4-Trimethylbenzene	NA	= ( 6.06E+00 × NV × 350 × 10.86 × [ 1 / 5.47E+03 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
1,3,5-Trimethylbenzene	NA	= ( 1.57E+01 × NV × 350 × 10.86 × [ 1 / 4.52E+03 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Benzene	1.82E-05	= ( 1.43E+01 × 2.73E-02 × 350 × 10.86 × [ 1 / 3.20E+03 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							
Xylenes (total)	NA	= ( 5.22E+01 × NV × 350 × 10.86 × [ 1 / 4.43E+03 + 1 / 6.58E+09 ] ) ÷ ( 25,550 )							

**Notes:**

Inh - Risk – Inhalation Risk

Csoil – Soil Concentration

SFi – Inhalation Slope Factor

EF – Exposure frequency

SinhRadj – Age-adjusted Soil Inhalation Rate

VF – Volatilization Factor

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

PEF – Particulate Emission Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 3b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Residential Child: Inhalation of Soil-derived Pathway (0-10 feet) – Noncarcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Csoil} \times \text{InhRc} \times \text{EF} \times \text{EDc} \times ([1/\text{VF}] + [1/\text{PEF}]))}{(\text{BWc} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= (	Csoil mg/kg	$\times$	InhRc m³/day	$\times$	EF days/year	$\times$	EDc year	$\times$	[ 1 / VF <sub>child</sub> m³/kg ]	+ 1 / PEF m³/kg ]	$\div$ (	BWc kg	$\times$	ATn days	$\times$	RfDi (b) mg/kg-day )
Arsenic	NA	= (	5.07E+00	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NA ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Lead	NA	= (	9.05E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NA ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	a )
Thallium	NA	= (	8.17E-01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NA ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
1-Methylnaphthalene	NA	= (	1.50E+02	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 1.47E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
2-Methylnaphthalene	NA	= (	1.44E+02	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 1.39E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Acenaphthene	NA	= (	3.64E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 2.68E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Benzo(a)anthracene	NA	= (	2.46E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Benzo(a)pyrene	NA	= (	1.95E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Benzo(b)fluoranthene	NA	= (	2.13E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Benzo(k)fluoranthene	NA	= (	1.01E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Chrysene	NA	= (	2.34E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Dibeno(a,h)anthracene	NA	= (	3.12E+00	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Dibenzofuran	NA	= (	9.93E+00	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 2.23E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Fluoranthene	NA	= (	6.36E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Fluorene	NA	= (	4.59E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 4.10E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Indeno(1,2,3-cd)pyrene	NA	= (	5.34E+00	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / NC ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Naphthalene	1.08E+01	= (	1.86E+02	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 1.29E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	8.57E-04 )
Phenanthrene	NA	= (	1.44E+02	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 6.54E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
Pyrene	NA	= (	8.56E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 1.36E+05 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	NV )
1,2,4-Trichlorobenzene	2.58E-01	= (	2.96E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 6.42E+04 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	1.14E-03 )
1,2,4-Trimethylbenzene	9.27E-01	= (	6.06E+00	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 2.44E+03 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	1.71E-03 )
1,3,5-Trimethylbenzene	2.92E-01	= (	1.57E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 2.02E+03 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	1.70E-02 )
Benzene	7.46E-01	= (	1.43E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 1.43E+03 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	8.57E-03 )
Xylenes (total)	5.88E-01	= (	5.22E+01	$\times$	10	$\times$	350	$\times$	6	$\times$	[ 1 / 1.98E+03 ]	+ 1 / 6.58E+09 ]	$\div$ (	15	$\times$	2,190	$\times$	2.86E-02 )

Notes:

Inh - Risk – Inhalation Hazard Quotient

PEF – Particulate Emission Factor

Csoil – Soil Concentration

BWc – Body Weight, child

InhRc – Inhalation Rate, child

ATn – Averaging Time for Noncarcinogens

EF – Exposure frequency

RfDi – Inhalation Reference Dose (subchronic)

EDc – Exposure duration, child

NV – No toxicity value available for this pathway.

VF – Volatilization Factor

NA – Not Applicable

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

## Attachment D

**Table 3c**  
**Residential Scenario: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^3}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T <sub>adult</sub> (s)	T <sub>child</sub> (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>3</sup> /cm <sup>3</sup> )	VF <sub>adult</sub> (m <sup>2</sup> /kg)
1-Methylnaphthalene	73.32	3.14	1.95E-05	9.46E+08	1.89E+08	2	1.38	1.00E-04	3.28E+04
2-Methylnaphthalene	73.32	3.14	2.17E-05	9.46E+08	1.89E+08	2	1.38	1.00E-04	3.11E+04
Acenaphthene	73.32	3.14	5.82E-06	9.46E+08	1.89E+08	2	1.38	1.00E-04	6.00E+04
Benzo(a)anthracene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Benzo(a)pyrene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Benzo(b)fluoranthene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Benzo(k)fluoranthene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Chrysene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Dibeno(a,h)anthracene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Dibenzofuran	73.32	3.14	8.46E-06	9.46E+08	1.89E+08	2	1.38	1.00E-04	4.98E+04
Fluoranthene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Fluorene	73.32	3.14	2.50E-06	9.46E+08	1.89E+08	2	1.38	1.00E-04	9.16E+04
Indeno(1,2,3-cd)pyrene	73.32	3.14	NC	9.46E+08	1.89E+08	2	1.38	1.00E-04	NC
Naphthalene	73.32	3.14	2.54E-05	9.46E+08	1.89E+08	2	1.38	1.00E-04	2.87E+04
Phenanthrene	73.32	3.14	9.79E-07	9.46E+08	1.89E+08	2	1.38	1.00E-04	1.46E+05
Pyrene	73.32	3.14	2.25E-07	9.46E+08	1.89E+08	2	1.38	1.00E-04	3.05E+05
1,2,4-Trichlorobenzene	73.32	3.14	1.02E-06	9.46E+08	1.89E+08	2	1.38	1.00E-04	1.44E+05
1,2,4-Trimethylbenzene	73.32	3.14	7.01E-04	9.46E+08	1.89E+08	2	1.38	1.00E-04	5.47E+03
1,3,5-Trimethylbenzene	73.32	3.14	1.02E-03	9.46E+08	1.89E+08	2	1.38	1.00E-04	4.52E+03
Benzene	73.32	3.14	2.05E-03	9.46E+08	1.89E+08	2	1.38	1.00E-04	3.20E+03
Xylenes (total)	73.32	3.14	1.07E-03	9.46E+08	1.89E+08	2	1.38	1.00E-04	4.43E+03

Notes:

Default values are as presented in Supplemental Guidance for Developing Soil

Screening Levels for Superfund Sites (USEPA 2002).

VF<sub>adult</sub> – Volatilization Factor (m<sup>2</sup>/kg) for adults (calculated)

VF<sub>child</sub> – Volatilization Factor (m<sup>2</sup>/kg) for children (calculated)

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source  
(g/m<sup>2</sup>-s)/(kg/m<sup>3</sup>) (Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T<sub>adult</sub> – Exposure interval (s) for adults

T<sub>child</sub> – Exposure interval (s) for children

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated; PAHs are not considered volatile chemicals

## Attachment D

**Table 3d**  
**Residential Scenario: Apparent Diffusivity Calculations**

Equation:

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H')}$$

Chemical Units	VOC?	$\theta_a$ (Lair /Lsoil )	$D_i$ (cm <sup>2</sup> /s)	$H'$ unitless	$\theta_w$ (Lwater /Lsoil )	$D_w$ (cm <sup>2</sup> /s)	$\eta$ (Lpore /Lsoil )	$\rho_b$ (g/cm <sup>3</sup> )	$\rho_s$ (g/cm <sup>3</sup> )	$K_d$ (cm <sup>3</sup> /g)	$D_A$ (cm <sup>2</sup> /s)
1-Methylnaphthalene	Yes	3.29E-01	6.31E-02	1.64E-02	0.15	7.13E-06	4.79E-01	1.38	2.65	3.75E+01	1.95E-05
2-Methylnaphthalene	Yes	3.29E-01	4.80E-02	2.12E-02	0.15	7.84E-06	4.79E-01	1.38	2.65	1.79E+01	2.17E-05
Acenaphthene	Yes	3.29E-01	4.21E-02	7.44E-03	0.15	7.69E-06	4.79E-01	1.38	2.65	3.67E+01	5.82E-06
Benz(a)anthracene	No	3.29E-01	5.10E-02	4.91E-04	0.15	9.00E-06	4.79E-01	1.38	2.65	1.39E+03	NC
Benz(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Benz(b)fluoranthene	No	3.29E-01	2.26E-02	2.69E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.82E+03	NC
Benz(k)fluoranthene	No	3.29E-01	2.26E-02	2.39E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Chrysene	No	3.29E-01	2.48E-02	2.14E-04	0.15	6.21E-06	4.79E-01	1.38	2.65	1.42E+03	NC
Dibenz(a,h)anthracene	No	3.29E-01	2.02E-02	5.03E-06	0.15	5.18E-06	4.79E-01	1.38	2.65	1.57E+04	NC
Dibenzofuran	Yes	3.29E-01	5.51E-02	8.71E-03	0.15	7.04E-06	4.79E-01	1.38	2.65	6.78E+01	8.46E-06
Fluoranthene	No	3.29E-01	3.02E-02	3.62E-04	0.15	6.35E-06	4.79E-01	1.38	2.65	4.25E+02	NC
Fluorene	Yes	3.29E-01	3.63E-02	3.93E-03	0.15	7.88E-06	4.79E-01	1.38	2.65	6.78E+01	2.50E-06
Indeno(1,2,3-cd)pyrene	No	3.29E-01	1.90E-02	1.42E-05	0.15	5.66E-06	4.79E-01	1.38	2.65	1.61E+04	NC
Naphthalene	Yes	3.29E-01	5.90E-02	1.80E-02	0.15	7.50E-06	4.79E-01	1.38	2.65	1.10E+01	2.54E-05
Phenanthrene	Yes	3.29E-01	3.33E-02	1.73E-03	0.15	7.47E-06	4.79E-01	1.38	2.65	1.25E+02	9.79E-07
Pyrene	Yes	3.29E-01	2.72E-02	4.87E-04	0.15	7.24E-06	4.79E-01	1.38	2.65	4.16E+02	2.25E-07
1,2,4-Trichlorobenzene	Yes	3.29E-01	3.00E-02	1.42E-03	0.15	8.23E-06	4.79E-01	1.38	2.65	1.07E+01	1.02E-06
1,2,4-Trimethylbenzene	Yes	3.29E-01	6.44E-02	2.52E-01	0.15	7.92E-06	4.79E-01	1.38	2.65	4.31E+00	7.01E-04
1,3,5-Trimethylbenzene	Yes	3.29E-01	6.02E-02	3.59E-01	0.15	8.67E-06	4.79E-01	1.38	2.65	4.22E+00	1.02E-03
Benzene	Yes	3.29E-01	8.80E-02	2.27E-01	0.15	9.80E-06	4.79E-01	1.38	2.65	9.93E-01	2.05E-03
Xylenes (total)	Yes	3.29E-01	7.14E-02	2.71E-01	0.15	9.34E-06	4.79E-01	1.38	2.65	2.66E+00	1.07E-03

Notes:

$D_A$  – apparent diffusivity

$K_d$  – soil-water partition coefficient, where:

$\theta_a$  – air-filled soil porosity

$K_d = Koc \times foc$

$D_i$  – diffusivity in air

$Koc$  – soil organic carbon partition coefficient (cm<sup>3</sup>/g)

$H'$  – dimensionless Henry's Law constant

$foc$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)

$\theta_w$  – water-filled soil porosity

VOC? – Volatile organic compounds; If no, an apparent diffusivity was not calculated.

$D_w$  – diffusivity in water

NV – no value available

$\eta$  – total soil porosity

NC – not calculated

$\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User'S Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).

$\rho_s$  – soil particle density

**Attachment D**  
**TABLE 3e**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**

**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface and Subsurface Soil**

**1. Lead Screening Questions**

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	90.5	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level
Water	4	ug/L	Model Default Value	15	ug/L	Recommended Drinking Water Action Level

**2. Lead Model Questions**

Question	Response for Residential Lead Model
What lead model (version and date) was used?	IEUBKwin v1.0 build 263; December 2005
Where are the input values located in the risk assessment report?	Located in Attachment A, Table 13.
What range of media concentrations were used for the model?	Average concentration was used for soil. Data are located in Attachment B1, Table 1.  Model default values were used for all other media.
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Average concentration was used for soil. Data are located in Table 4-8A and 4-8B of the RI Report.
Was soil sample taken from top 2 cm? If not, why?	No. As outlined in the approved RI/FS Workplan (URS, 2005), residential receptors are assumed to be exposed to exposed soil at depths between 0 and 10 feet.
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No. Samples were prepared in accordance with the Field Sampling Plan approved by the USEPA.
What was the point of exposure/location?	Samples were collected from the upper bluff area near the former ravine.
Where are the output values located in the risk assessment report?	Located in Attachment B8.
Was the model run using default values only?	No. Site-specific soil concentration values used. All other model values are default.
Was the default soil bioavailability used?	Yes. Default is 30%
Was the default soil ingestion rate used?	Yes. Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day.
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Not applicable to this evaluation.

**3. Final Result**

Medium	Result	Comment/PRG
Surface Soil and Groundwater	Input value of 88.74 mg/kg in surface soil and 4 ug/L in groundwater results in 0.128% of residential children above a blood lead level of 10 ug/dL. Geometric mean blood lead = 2.423 ug/dL. This does not exceed the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 ug/dL blood lead.	

**Attachment D**  
**TABLE 3e**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**

**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface and Subsurface Soil**

**LEAD MODEL FOR WINDOWS Version 1.0**

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Model Version: 1.0 Build 263

User Name:

Date:

Site Name:

Operable Unit:

Run Mode: Research

---

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

\*\*\*\*\* Air \*\*\*\*\*

Indoor Air Pb Concentration: 30.000 percent of outdoor.

Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

\*\*\*\*\* Diet \*\*\*\*\*

Age    Diet Intake(ug/day)

.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

\*\*\*\*\* Drinking Water \*\*\*\*\*

Water Consumption:

Age    Water (L/day)

.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

**Attachment D**  
**TABLE 3e**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**

**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface and Subsurface Soil**

\*\*\*\*\* Soil & Dust \*\*\*\*\*

Multiple Source Analysis Used

Average multiple source concentration: 73.350 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000

Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
-----	----------------	----------------------

.5-1	90.500	73.350
1-2	90.500	73.350
2-3	90.500	73.350
3-4	90.500	73.350
4-5	90.500	73.350
5-6	90.500	73.350
6-7	90.500	73.350

\*\*\*\*\* Alternate Intake \*\*\*\*\*

Age	Alternate (ug Pb/day)
-----	-----------------------

.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

\*\*\*\*\* Maternal Contribution: Infant Model \*\*\*\*\*

Maternal Blood Concentration: 2.500 ug Pb/dL

\*\*\*\*\* CALCULATED BLOOD LEAD AND LEAD UPTAKES: \*\*\*\*\*

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.614	0.000	0.378
1-2	0.034	2.724	0.000	0.943
2-3	0.062	3.076	0.000	0.986
3-4	0.067	2.982	0.000	1.013
4-5	0.067	2.903	0.000	1.063
5-6	0.093	3.074	0.000	1.125
6-7	0.093	3.400	0.000	1.146

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	1.954	4.967	2.7
1-2	3.095	6.795	2.9
2-3	3.113	7.237	2.7
3-4	3.138	7.200	2.5
4-5	2.350	6.382	2.2
5-6	2.123	6.416	2.0
6-7	2.008	6.647	1.9

**Attachment D**  
**Table 3f**  
**Calculations of Blood Lead Concentrations (PbBs)**  
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee  
Version date 05/19/03

Exposure Variable	PbB Equation <sup>1</sup>		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario					
					Using Equation 1		Using Equation 2			
	1*	2**			GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het	GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het		
PbS	X	X	Soil lead concentration	ug/g or ppm	94.08	94.08	94.08	94.08		
R <sub>fetal/maternal</sub>	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9		
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4		
GSD <sub>i</sub>	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3		
PbB <sub>0</sub>	X	X	Baseline PbB	ug/dL	1.5	1.7	1.5	1.7		
IR <sub>S</sub>	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--		
IR <sub>S+D</sub>		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050		
W <sub>S</sub>		X	Weighting factor; fraction of IR <sub>S+D</sub> ingested as outdoor soil	--	--	--	1.0	1.0		
K <sub>SD</sub>		X	Mass fraction of soil in dust	--	--	--	0.7	0.7		
AF <sub>S, D</sub>	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12		
EF <sub>S, D</sub>	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219		
AT <sub>S, D</sub>	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365		
<b>PbB<sub>adult</sub></b>	<b>PbB of adult worker, geometric mean</b>			<b>ug/dL</b>	<b>1.6</b>	<b>1.8</b>	<b>1.6</b>	<b>1.8</b>		
<b>PbB<sub>fetal, 0.95</sub></b>	<b>95th percentile PbB among fetuses of adult workers</b>			<b>ug/dL</b>	<b>5.0</b>	<b>6.5</b>	<b>5.0</b>	<b>6.5</b>		
<b>PbB<sub>t</sub></b>	<b>Target PbB level of concern (e.g., 10 ug/dL)</b>			<b>ug/dL</b>	<b>10.0</b>	<b>10.0</b>	<b>10.0</b>	<b>10.0</b>		
<b>P(PbB<sub>fetal</sub> &gt; PbB<sub>t</sub>)</b>	<b>Probability that fetal PbB &gt; PbB<sub>t</sub>, assuming lognormal distribution</b>			<b>%</b>	<b>0.5%</b>	<b>1.5%</b>	<b>0.5%</b>	<b>1.5%</b>		

<sup>1</sup> Equation 1 does not apportion exposure between soil and dust ingestion (excludes W<sub>S</sub>, K<sub>SD</sub>).

When IR<sub>S</sub> = IR<sub>S+D</sub> and W<sub>S</sub> = 1.0, the equations yield the same PbB<sub>fetal,0.95</sub>.

\*Equation 1, based on Eq. 1, 2 in USEPA (1996).

<b>PbB<sub>adult</sub> =</b>	(PbS*BKSF*IR <sub>S+D</sub> *AF <sub>S,D</sub> *EF <sub>S</sub> /AT <sub>S,D</sub> ) + PbB <sub>0</sub>
<b>PbB<sub>fetal, 0.95</sub> =</b>	PbB <sub>adult</sub> * (GSD <sub>i</sub> <sup>1.645</sup> * R)

\*\*Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).

<b>PbB<sub>adult</sub> =</b>	PbS*BKSF*([(IR <sub>S+D</sub> )*AF <sub>S</sub> *EF <sub>S</sub> *W <sub>S</sub> ] + [K <sub>SD</sub> *(IR <sub>S+D</sub> )*(1-W <sub>S</sub> )*AF <sub>D</sub> *EF <sub>D</sub> ])/365 + PbB <sub>0</sub> )
<b>PbB<sub>fetal, 0.95</sub> =</b>	PbB <sub>adult</sub> * (GSD <sub>i</sub> <sup>1.645</sup> * R)

**Attachment D**  
**TABLE 3g**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**  
**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface Soil**

**1. Lead Screening Questions**

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	83.4	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level
Water	4	ug/L	Model Default Value	15	ug/L	Recommended Drinking Water Action Level

**2. Lead Model Questions**

Question	Response for Residential Lead Model
What lead model (version and date) was used?	IEUBKwin v1.0 build 263; December 2005
Where are the input values located in the risk assessment report?	Located in Attachment A, Table 13.
What range of media concentrations were used for the model?	Average concentration was used for soil. Data are located in Attachment B1, Table 1.  Model default values were used for all other media.
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Average concentration was used for soil. Data are located in Table 4-8A and 4-8B of the RI Report.
Was soil sample taken from top 2 cm? If not, why?	No. As outlined in the approved RI/FS Workplan (URS, 2005), residential receptors are assumed to be exposed to exposed soil at depths between 0 and 10 feet.
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No. Samples were prepared in accordance with the Field Sampling Plan approved by the USEPA.
What was the point of exposure/location?	Samples were collected from the upper bluff area near the former ravine.
Where are the output values located in the risk assessment report?	Located in Attachment B8.
Was the model run using default values only?	No. Site-specific soil concentration values used. All other model values are default.
Was the default soil bioavailability used?	Yes. Default is 30%
Was the default soil ingestion rate used?	Yes Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day.
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Not applicable to this evaluation.

**3. Final Result**

Medium	Result	Comment/PRG
Surface Soil and Groundwater	Input value of 83.4 mg/kg in surface soil and 4 ug/L in groundwater results in 0.105% of residential children above a blood lead level of 10 ug/dL. Geometric mean blood lead = 2.357 ug/dL. This does not exceed the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 ug/dL blood lead.	

**Attachment D**  
**TABLE 3g**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**  
**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface Soil**

**LEAD MODEL FOR WINDOWS Version 1.0**

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Model Version: 1.0 Build 263

User Name:

Date:

Site Name:

Operable Unit:

Run Mode: Research

---

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

\*\*\*\*\* Air \*\*\*\*\*

Indoor Air Pb Concentration: 30.000 percent of outdoor.

Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

\*\*\*\*\* Diet \*\*\*\*\*

Age    Diet Intake(ug/day)

.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

\*\*\*\*\* Drinking Water \*\*\*\*\*

Water Consumption:

Age    Water (L/day)

.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

**Attachment D**  
**TABLE 3g**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**  
**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface Soil**

**Attachment D**  
**TABLE 3g**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**  
**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface Soil**

\*\*\*\*\* Soil & Dust \*\*\*\*\*

Multiple Source Analysis Used

Average multiple source concentration: 68.380 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000

Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	83.400	68.380
1-2	83.400	68.380
2-3	83.400	68.380
3-4	83.400	68.380
4-5	83.400	68.380
5-6	83.400	68.380
6-7	83.400	68.380

\*\*\*\*\* Alternate Intake \*\*\*\*\*

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

\*\*\*\*\* Maternal Contribution: Infant Model \*\*\*\*\*

Maternal Blood Concentration: 2.500 ug Pb/dL

\*\*\*\*\* CALCULATED BLOOD LEAD AND LEAD UPTAKES: \*\*\*\*\*

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.618	0.000	0.379
1-2	0.034	2.729	0.000	0.944
2-3	0.062	3.081	0.000	0.988
3-4	0.067	2.986	0.000	1.015
4-5	0.067	2.906	0.000	1.064
5-6	0.093	3.077	0.000	1.126
6-7	0.093	3.402	0.000	1.147

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	1.814	4.832	2.6
1-2	2.874	6.581	2.8
2-3	2.890	7.021	2.6
3-4	2.913	6.980	2.5
4-5	2.180	6.216	2.2

**Attachment D**  
**TABLE 3g**  
**(RAGS D IEUBK LEAD WORKSHEET)**  
**Site Name: NSP Ashland Lakefront**  
**Receptor: Residential Child (Age 0 - 84 Months) Exposure to Surface Soil**

5-6	1.969	6.265	2.0
6-7	1.862	6.504	1.8

## Attachment D

**Table 4a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adult: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(C_{\text{soil}} \times SF_{\text{o}} \times CF \times EF \times ED \times SIR \times FI)}{(BW \times ATc)}$$

Equation Units	Ing - Risk unitless	= (	C <sub>soil</sub> mg/kg	×	SF <sub>o</sub> kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Arsenic	1.79E-07	= (	5.48E+00	×	1.50E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Cadmium	NA	= (	1.35E+00	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Iron	NA	= (	2.55E+04	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Lead	NA	= (	1.08E+02	×	a	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Manganese	NA	= (	3.47E+02	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Thallium	NA	= (	1.04E+00	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Vanadium	NA	= (	3.66E+01	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Zinc	NA	= (	4.61E+02	×	NV	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Benzo(a)anthracene	5.74E-08	= (	3.60E+00	×	7.30E-01	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Benzo(a)pyrene	1.13E-06	= (	7.10E+00	×	7.30E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Benzo(b)fluoranthene	1.09E-07	= (	6.85E+00	×	7.30E-01	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Benzo(k)fluoranthene	3.07E-09	= (	1.93E+00	×	7.30E-02	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550
Indeno(1,2,3-cd)pyrene	7.52E-08	= (	4.72E+00	×	7.30E-01	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	25,550

**Notes:**

Ing - Risk – Ingestion risk

C<sub>soil</sub> – Soil Concentration

SF<sub>o</sub> – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SIR – Soil Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 4b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adult: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo <sup>(b)</sup> mg/kg-day	)
Aluminum	4.85E-04	= (	9.53E+03	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	1.0E+00	)
Arsenic	9.30E-04	= (	5.48E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	3.0E-04	)
Cadmium	6.89E-05	= (	1.35E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	1.0E-03	)
Iron	4.32E-03	= (	2.55E+04	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	3.0E-01	)
Lead	NA	= (	1.08E+02	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	a	)
Manganese	1.26E-04	= (	3.47E+02	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	1.4E-01	)
Thallium	6.60E-05	= (	1.04E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	8.0E-04	)
Vanadium	2.66E-04	= (	3.66E+01	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	7.0E-03	)
Zinc	7.82E-05	= (	4.61E+02	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	3.0E-01	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	NV	)
Benzo(a)pyrene	NA	= (	7.10E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	NV	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1E-06	×	52	×	30	×	50	×	0.5	) ÷ (	70	×	10,950	×	NV	)

**Notes:**

Ing - HQ – Ingestion Hazard

Csoil – Soil Concentration

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Soil Ingestion Rate

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 5a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adult: Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csoil} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSD})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Derm - Risk unless	= (	Csoil mg/kg	×	SFabs kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSD unlessless	)	÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Arsenic	6.94E-08	= (	5.48E+00	×	1.58E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	3.00E-02	)	÷ (	70	×	25,550
Cadmium	NA	= (	1.35E+00	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.00E-03	)	÷ (	70	×	25,550
Iron	NA	= (	2.55E+04	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Lead	NA	= (	1.08E+02	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Manganese	NA	= (	3.47E+02	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Thallium	NA	= (	1.04E+00	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Vanadium	NA	= (	3.66E+01	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Zinc	NA	= (	4.61E+02	×	NV	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	)	÷ (	70	×	25,550
Benzo(a)anthracene	9.13E-08	= (	3.60E+00	×	7.30E-01	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	)	÷ (	70	×	25,550
Benzo(a)pyrene	1.80E-06	= (	7.10E+00	×	7.30E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	)	÷ (	70	×	25,550
Benzo(b)fluoranthene	1.74E-07	= (	6.85E+00	×	7.30E-01	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	)	÷ (	70	×	25,550
Benzo(k)fluoranthene	4.88E-09	= (	1.93E+00	×	7.30E-02	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	)	÷ (	70	×	25,550
Indeno(1,2,3-cd)pyrene	1.20E-07	= (	4.72E+00	×	7.30E-01	×	1E-06	×	52	×	30	×	1	×	4373	×	0.1	×	1.30E-01	)	÷ (	70	×	25,550

**Notes:**

Derm - Risk – Dermal Risk

Csoil – Soil Concentration

SFabs – Absorbed slope factor (SFo ÷ ABSgi)

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SA – Skin Surface Area

SSAF – Soil-to-skin Adherence Factor

ABSD – Dermal Soil Absorption Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

## Attachment D

**Table 5b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adult: Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSD})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSD unitless	) ÷ (	BW kg	×	ATn days	×	RfDabs (b) mg/kg-day	)
Aluminum	NA	= (	9.53E+03	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	NV	)
Arsenic	3.60E-04	= (	5.48E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	3.00E-02	) ÷ (	70	×	10,950	×	2.85E-04	)
Cadmium	3.37E-05	= (	1.35E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.00E-03	) ÷ (	70	×	10,950	×	2.50E-05	)
Iron	NA	= (	2.55E+04	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	NV	)
Lead	NA	= (	1.08E+02	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	NV	)
Manganese	NA	= (	3.47E+02	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	5.60E-03	)
Thallium	NA	= (	1.04E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	8.00E-04	)
Vanadium	NA	= (	3.66E+01	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	1.82E-04	)
Zinc	NA	= (	4.61E+02	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	NA	) ÷ (	70	×	10,950	×	3.00E-01	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	70	×	10,950	×	NV	)
Benzo(a)pyrene	NA	= (	7.10E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	70	×	10,950	×	NV	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	70	×	10,950	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	70	×	10,950	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1E-06	×	52	×	30	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	70	×	10,950	×	NV	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

Csoil – Soil Concentration

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

ABSD – Dermal Soil Absorption Factor

BW – Body Weight

ATn – Averaging time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo × ABSgi)

NA – Not Applicable

NV – No toxicity value available for this pathway.

SSAF – Soil-to-skin Adherence Factor

## Attachment D

**Table 6a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adult: Inhalation of Soil -Derived Chemicals Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFI} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unitsless	= (	Csoil mg/kg	×	SFI kg-day/mg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / VF m³/kg	+ 1 / PEF m³/kg	] ) ÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Arsenic	1.09E-10	= (	5.48E+00	×	1.51E+01	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Cadmium	1.13E-11	= (	1.35E+00	×	6.30E+00	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Iron	NA	= (	2.55E+04	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Lead	NA	= (	1.08E+02	×	a	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Manganese	NA	= (	3.47E+02	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Thallium	NA	= (	1.04E+00	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Vanadium	NA	= (	3.66E+01	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Zinc	NA	= (	4.61E+02	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Benzo(a)anthracene	NA	= (	3.60E+00	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Benzo(a)pyrene	2.90E-11	= (	7.10E+00	×	3.08E+00	×	1.00	×	2	×	52	×	30	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	NV	×	1.00	×	2	×	52	×	30	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	70	×	25,550 )

Notes:

Inh - Risk – Inhalation Risk

Csoil – Soil Concentration

SFI – Inhalation Slope Factor

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

VF – Volatilization Factor

PEF – Particulate Emission Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 6b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adult: Inhalation of Soil-Derived Chemicals Pathway – Noncarcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Csoil} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times ([1/\text{VF}] + [1/\text{PEF}]))}{(\text{BW} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= (	Csoil mg/kg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / ]	VF m³/kg	+ 1 / ]	PEF m³/kg	] ÷ (	BW kg	×	ATn days	×	RfDi <sup>(b)</sup> mg/kg-day
Aluminum	2.06E-05	= (	9.53E+03	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	1.43E-03 )
Arsenic	NA	= (	5.48E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Cadmium	1.61E-08	= (	1.35E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	2.60E-04 )
Iron	NA	= (	2.55E+04	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Lead	NA	= (	1.08E+02	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	a )
Manganese	7.52E-05	= (	3.47E+02	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	1.43E-05 )
Thallium	NA	= (	1.04E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Vanadium	NA	= (	3.66E+01	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Zinc	NA	= (	4.61E+02	×	1	×	2	×	52	×	30	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Benzo(a)anthracene	NA	= (	3.60E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Benzo(a)pyrene	NA	= (	7.10E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1	×	2	×	52	×	30	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	70	×	10,950	×	NV )

**Notes:**

Inh - Risk – Inhalation Hazard Quotient

Csoil – Soil Concentration

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

VF – Volatilization Factor

PEF – Particulate Emission Factor

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDi – Inhalation Reference Dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

## Attachment D

**Table 6c**  
**Recreational Scenario: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^3}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>2</sup> /cm <sup>2</sup> )	VF (m <sup>2</sup> /kg)
Benzo(a)anthracene	73.32	3.14	NC	9.46E+08	2	1.38	1.00E-04	NC
Benzo(a)pyrene	73.32	3.14	NC	9.46E+08	2	1.38	1.00E-04	NC
Benzo(b)fluoranthene	73.32	3.14	NC	9.46E+08	2	1.38	1.00E-04	NC
Benzo(k)fluoranthene	73.32	3.14	NC	9.46E+08	2	1.38	1.00E-04	NC
Indeno(1,2,3-cd)pyrene	73.32	3.14	NC	9.46E+08	2	1.38	1.00E-04	NC

Notes: Default values are as presented in Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002).

VF – Volatilization Factor (m<sup>2</sup>/kg) (calculated)

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source  
(g/m<sup>2</sup>-s)/(kg/m<sup>3</sup>)(Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T – Exposure interval (s)

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated; PAHs are not considered volatile chemicals

## Attachment D

**Table 6d**  
**Recreational Scenario: Apparent Diffusivity Calculations**

Equation:

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H')}$$

Chemical	VOC?	$\theta_a$	$D_i$	$H'$	$\theta_w$	$D_w$	$\eta$	$\rho_b$	$\rho_s$	$K_d$	$D_A$
Units		(Lair / Lsoil )	(cm <sup>2</sup> /s)	unitless	(Lwater / Lsoil )	(cm <sup>2</sup> /s)	(Lpore / Lsoil )	(g/cm <sup>3</sup> )	(g/cm <sup>3</sup> )	(cm <sup>3</sup> /g )	(cm <sup>2</sup> /s)
Benzo(a)anthracene	No	3.29E-01	5.10E-02	4.91E-04	0.15	9.00E-06	4.79E-01	1.38	2.65	1.39E+03	NC
Benzo(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Benzo(b)fluoranthene	No	3.29E-01	2.26E-02	2.69E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.82E+03	NC
Benzo(k)fluoranthene	No	3.29E-01	4.90E-02	1.35E-05	0.15	5.65E-05	4.79E-01	1.38	2.65	1.61E+04	NC
Indeno(1,2,3-cd)pyrene	No	3.29E-01	1.90E-02	1.42E-05	0.15	5.66E-06	4.79E-01	1.38	2.65	1.61E+04	NC

Notes:

$D_A$  – apparent diffusivity

$\theta_a$  – air-filled soil porosity

$D_i$  – diffusivity in air

$H'$  – dimensionless Henry's law constant

$\theta_w$  – water-filled soil porosity

$D_w$  – diffusivity in water

$\eta$  – total soil porosity

$\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User'S Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).

$\rho_s$  – soil particle density

$K_d$  – soil-water partition coefficient, where:

$$K_d = K_{oc} \times f_{oc}$$

$K_{oc}$  – soil organic carbon partition coefficient (cm<sup>3</sup>/g)

$f_{oc}$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)

VOC? – Volatile organic compounds; If no, an apparent diffusivity was not calculated.

NV – no value available

NC – not calculated

## Attachment D

**Table 7a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adolescent: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(C_{\text{soil}} \times SF_{\text{o}} \times CF \times EF \times ED \times SIR \times FI)}{(BW \times ATc)}$$

Equation Units	Ing - Risk unitless	= (	C <sub>soil</sub> mg/kg	×	SF <sub>o</sub> kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Arsenic	1.07E-07	= (	5.48E+00	×	1.50E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Cadmium	NA	= (	1.35E+00	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Iron	NA	= (	2.55E+04	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Lead	NA	= (	1.08E+02	×	a	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Manganese	NA	= (	3.47E+02	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Thallium	NA	= (	1.04E+00	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Vanadium	NA	= (	3.66E+01	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Zinc	NA	= (	4.61E+02	×	NV	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Benzo(a)anthracene	3.42E-08	= (	3.60E+00	×	7.30E-01	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Benzo(a)pyrene	6.73E-07	= (	7.10E+00	×	7.30E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Benzo(b)fluoranthene	6.50E-08	= (	6.85E+00	×	7.30E-01	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Benzo(k)fluoranthene	1.83E-09	= (	1.93E+00	×	7.30E-02	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550
Indeno(1,2,3-cd)pyrene	4.48E-08	= (	4.72E+00	×	7.30E-01	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	25,550

**Notes:**

Ing - Risk – Ingestion risk

C<sub>soil</sub> – Soil Concentration

SF<sub>o</sub> – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SIR – Soil Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 7b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adolescent: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo <sup>(b)</sup> mg/kg-day	)
Aluminum	7.23E-04	= (	9.53E+03	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	1.0E+00	)
Arsenic	1.39E-03	= (	5.48E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	3.0E-04	)
Cadmium	1.03E-04	= (	1.35E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	1.0E-03	)
Iron	6.43E-03	= (	2.55E+04	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	3.0E-01	)
Lead	NA	= (	1.08E+02	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	a	)
Manganese	1.88E-04	= (	3.47E+02	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	1.4E-01	)
Thallium	9.83E-05	= (	1.04E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	8.0E-04	)
Vanadium	3.96E-04	= (	3.66E+01	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	7.0E-03	)
Zinc	1.17E-04	= (	4.61E+02	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	3.0E-01	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	NV	)
Benzo(a)pyrene	NA	= (	7.10E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	NV	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1E-06	×	52	×	12	×	50	×	0.5	) ÷ (	47	×	4,380	×	NV	)

**Notes:**

Ing - HQ – Ingestion Hazard

Csoil – Soil Concentration

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Soil Ingestion Rate

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 8a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adolescent: Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csoil} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSD})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Derm - Risk unless	= (	Csoil mg/kg	×	SFabs kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSD unless	) ÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Arsenic	9.54E-09	= (	5.48E+00	×	1.58E+00	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	3.00E-02	) ÷ (	47	×	25,550
Cadmium	NA	= (	1.35E+00	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	1.00E-03	) ÷ (	47	×	25,550
Iron	NA	= (	2.55E+04	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Lead	NA	= (	1.08E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Manganese	NA	= (	3.47E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Thallium	NA	= (	1.04E+00	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Vanadium	NA	= (	3.66E+01	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Zinc	NA	= (	4.61E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	25,550
Benzo(a)anthracene	1.26E-08	= (	3.60E+00	×	7.30E-01	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	25,550
Benzo(a)pyrene	2.47E-07	= (	7.10E+00	×	7.30E+00	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	25,550
Benzo(b)fluoranthene	2.39E-08	= (	6.85E+00	×	7.30E-01	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	25,550
Benzo(k)fluoranthene	6.71E-10	= (	1.93E+00	×	7.30E-02	×	1E-06	×	12	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	25,550
Indeno(1,2,3-cd)pyrene	1.65E-08	= (	4.72E+00	×	7.30E-01	×	1E-06	×	12	×	12	×	1	×	4373	×	0.1	×	1.30E-01	) ÷ (	47	×	25,550

**Notes:**

Derm - Risk – Dermal Risk

Csoil – Soil Concentration

SFabs – Absorbed slope factor (SFo ÷ ABSgi)

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SA – Skin Surface Area

SSAF – Soil-to-skin Adherence Factor

ABSD – Dermal Soil Absorption Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

**Attachment D**

**Table 8b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adolescent: Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(C_{\text{soil}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATn \times RfDabs)}$$

Equation Units	Derm - HQ unitless	= (	C <sub>soil</sub> mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSd unitless	) ÷ (	BW kg	×	ATn days	×	RfDabs (b) mg/kg-day	)
Aluminum	NA	= (	9.53E+03	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	NV	)
Arsenic	5.36E-04	= (	5.48E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	3.00E-02	) ÷ (	47	×	4,380	×	2.85E-04	)
Cadmium	5.03E-05	= (	1.35E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	1.00E-03	) ÷ (	47	×	4,380	×	2.50E-05	)
Iron	NA	= (	2.55E+04	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	NV	)
Lead	NA	= (	1.08E+02	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	NV	)
Manganese	NA	= (	3.47E+02	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	5.60E-03	)
Thallium	NA	= (	1.04E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	8.00E-04	)
Vanadium	NA	= (	3.66E+01	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	1.82E-04	)
Zinc	NA	= (	4.61E+02	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	NA	) ÷ (	47	×	4,380	×	3.00E-01	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	4,380	×	NV	)
Benzo(a)pyrene	NA	= (	7.10E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	4,380	×	NV	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	4,380	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	4,380	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1E-06	×	52	×	12	×	1	×	4,373	×	0.1	×	1.30E-01	) ÷ (	47	×	4,380	×	NV	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

C<sub>soil</sub> – Soil Concentration

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

ABSD – Dermal Soil Absorption Factor

BW – Body Weight

ATn – Averaging time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo × ABSgi)

NA – Not Applicable

NV – No toxicity value available for this pathway.

SSAF – Soil-to-skin Adherence Factor

## Attachment D

**Table 9a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adolescent: Inhalation of Soil -Derived Chemicals Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFI} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unithless	= (	Csoil mg/kg	×	SFI kg-day/mg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / VF m³/kg	+ 1 / PEF m³/kg	] ) ÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Arsenic	6.52E-11	= (	5.48E+00	×	1.51E+01	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Cadmium	6.74E-12	= (	1.35E+00	×	6.30E+00	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Iron	NA	= (	2.55E+04	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Lead	NA	= (	1.08E+02	×	a	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Manganese	NA	= (	3.47E+02	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Thallium	NA	= (	1.04E+00	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Vanadium	NA	= (	3.66E+01	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Zinc	NA	= (	4.61E+02	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Benzo(a)pyrene	1.73E-11	= (	7.10E+00	×	3.08E+00	×	1.00	×	2	×	52	×	12	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	NV	×	1.00	×	2	×	52	×	12	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	47 ×	25,550	)

Notes:

Inh - Risk – Inhalation Risk

Csoil – Soil Concentration

SFI – Inhalation Slope Factor

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

VF – Volatilization Factor

PEF – Particulate Emission Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 9b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Adolescent: Inhalation of Soil-Derived Chemicals Pathway – Noncarcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Csoil} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times ([1/\text{VF}] + [1/\text{PEF}]))}{(\text{BW} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= (	Csoil mg/kg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / ]	VF m³/kg	+ 1 / ]	PEF m³/kg	] ÷ (	BW kg	×	ATn days	×	RfDi <sup>(b)</sup> mg/kg-day
Links Only	NA	= (	–	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	1.43E-03 )
Aluminum	3.07E-05	= (	9.53E+03	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	1.43E-03 )
Arsenic	NA	= (	5.48E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Cadmium	2.40E-08	= (	1.35E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	2.60E-04 )
Iron	NA	= (	2.55E+04	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Lead	NA	= (	1.08E+02	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	a )
Manganese	1.12E-04	= (	3.47E+02	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	1.43E-05 )
Thallium	NA	= (	1.04E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Vanadium	NA	= (	3.66E+01	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Zinc	NA	= (	4.61E+02	×	1	×	2	×	52	×	12	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Benzo(a)anthracene	NA	= (	3.60E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Benzo(a)pyrene	NA	= (	7.10E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1	×	2	×	52	×	12	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	47	×	4,380	×	NV )

Notes:

Inh - Risk – Inhalation Hazard Quotient

Csoil – Soil Concentration

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

VF – Volatilization Factor

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

PEF – Particulate Emission Factor

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDi – Inhalation Reference Dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 9c**  
**Recreational Scenario: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^3}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>2</sup> /cm <sup>2</sup> )	VF (m <sup>2</sup> /kg)
Benzo(a)anthracene	73.32	3.14	NC	3.78E+08	2	1.38	1.00E-04	NC
Benzo(a)pyrene	73.32	3.14	NC	3.78E+08	2	1.38	1.00E-04	NC
Benzo(b)fluoranthene	73.32	3.14	NC	3.78E+08	2	1.38	1.00E-04	NC
Benzo(k)fluoranthene	73.32	3.14	NC	3.78E+08	2	1.38	1.00E-04	NC
Indeno(1,2,3-cd)pyrene	73.32	3.14	NC	3.78E+08	2	1.38	1.00E-04	NC

Notes: Default values are as presented in Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002).

VF – NA

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source  
(g/m<sup>2</sup>-s)/(kg/m<sup>3</sup>)(Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T – Exposure interval (s)

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated; PAHs are not considered volatile chemicals

## Attachment D

**Table 9d**  
**Recreational Scenario: Apparent Diffusivity Calculations**

**Equation:**

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H')}$$

Chemical	VOC?	$\theta_a$	$D_i$	$H'$	$\theta_w$	$D_w$	$\eta$	$\rho_b$	$\rho_s$	$K_d$	$D_A$
Units		(Lair /Lsoil )	(cm <sup>2</sup> /s)	unitless	(Lwater /Lsoil )	(cm <sup>2</sup> /s)	(Lpore /Lsoil )	(g/cm <sup>3</sup> )	(g/cm <sup>3</sup> )	(cm <sup>3</sup> /g )	(cm <sup>2</sup> /s)
Benzo(a)anthracene	No	3.29E-01	5.10E-02	4.91E-04	0.15	9.00E-06	4.79E-01	1.38	2.65	1.39E+03	NC
Benzo(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Benzo(b)fluoranthene	No	3.29E-01	2.26E-02	2.69E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.82E+03	NC
Benzo(k)fluoranthene	No	3.29E-01	4.90E-02	1.35E-05	0.15	5.65E-05	4.79E-01	1.38	2.65	1.61E+04	NC
Indeno(1,2,3-cd)pyrene	No	3.29E-01	1.90E-02	1.42E-05	0.15	5.66E-06	4.79E-01	1.38	2.65	1.61E+04	NC

Notes:

$D_A$  – apparent diffusivity

$\theta_a$  – air-filled soil porosity

$D_i$  – diffusivity in air

$H'$  – dimensionless Henry's law constant

$\theta_w$  – water-filled soil porosity

$D_w$  – diffusivity in water

$\eta$  – total soil porosity

$\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User's Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).

$\rho_s$  – soil particle density

$K_d$  – soil-water partition coefficient, where:

$$K_d = K_{oc} \times f_{oc}$$

$K_{oc}$  – soil organic carbon partition coefficient (cm<sup>3</sup> /g)

$f_{oc}$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)

VOC? – Volatile organic compounds; If no, an apparent diffusivity was not calculated.

NV – no value available

NC – not calculated

## Attachment D

**Table 10a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Child: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(C_{\text{soil}} \times SF_{\text{o}} \times CF \times EF \times ED \times SIR \times FI)}{(BW \times ATc)}$$

Equation Units	Ing - Risk unitless	= (	C <sub>soil</sub> mg/kg	×	SF <sub>o</sub> kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Arsenic	1.34E-06	= (	5.48E+00	×	1.50E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Cadmium	NA	= (	1.35E+00	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Iron	NA	= (	2.55E+04	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Lead	NA	= (	1.08E+02	×	a	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Manganese	NA	= (	3.47E+02	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Thallium	NA	= (	1.04E+00	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Vanadium	NA	= (	3.66E+01	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Zinc	NA	= (	4.61E+02	×	NV	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Benzo(a)anthracene	4.28E-07	= (	3.60E+00	×	7.30E-01	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Benzo(a)pyrene	8.44E-06	= (	7.10E+00	×	7.30E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Benzo(b)fluoranthene	8.15E-07	= (	6.85E+00	×	7.30E-01	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Benzo(k)fluoranthene	2.29E-08	= (	1.93E+00	×	7.30E-02	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550
Indeno(1,2,3-cd)pyrene	5.61E-07	= (	4.72E+00	×	7.30E-01	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	25,550

**Notes:**

Ing - Risk – Ingestion risk

C<sub>soil</sub> – Soil Concentration

SF<sub>o</sub> – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SIR – Soil Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 10b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Child: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo <sup>(b)</sup> mg/kg-day	)
Aluminum	1.81E-02	= (	9.53E+03	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	1.0E+00	)
Arsenic	3.47E-02	= (	5.48E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	3.0E-04	)
Cadmium	2.57E-03	= (	1.35E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	1.0E-03	)
Iron	1.61E-01	= (	2.55E+04	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	3.0E-01	)
Lead	NA	= (	1.08E+02	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	a	)
Manganese	4.71E-03	= (	3.47E+02	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	1.4E-01	)
Thallium	2.46E-03	= (	1.04E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	8.0E-04	)
Vanadium	9.92E-03	= (	3.66E+01	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	7.0E-03	)
Zinc	2.92E-03	= (	4.61E+02	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	3.0E-01	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	NV	)
Benzo(a)pyrene	NA	= (	7.10E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	NV	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1E-06	×	52	×	6	×	400	×	0.5	) ÷ (	15	×	2,190	×	NV	)

**Notes:**

Ing - HQ – Ingestion Hazard

Csoil – Soil Concentration

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Soil Ingestion Rate

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 11a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Child: Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(C_{\text{soil}} \times SF_{\text{abs}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATc)}$$

Equation Units	Derm - Risk unless	= (	C <sub>soil</sub> mg/kg	×	SF <sub>abs</sub> kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSd unitless	)	÷ (	BW kg	×	ATc days
Aluminum	NA	= (	9.53E+03	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Arsenic	1.18E-07	= (	5.48E+00	×	1.58E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	3.00E-02	)	÷ (	15	×	25,550
Cadmium	NA	= (	1.35E+00	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.00E-03	)	÷ (	15	×	25,550
Iron	NA	= (	2.55E+04	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Lead	NA	= (	1.08E+02	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Manganese	NA	= (	3.47E+02	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Thallium	NA	= (	1.04E+00	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Vanadium	NA	= (	3.66E+01	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Zinc	NA	= (	4.61E+02	×	NV	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	)	÷ (	15	×	25,550
Benzo(a)anthracene	1.56E-07	= (	3.60E+00	×	7.30E-01	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	)	÷ (	15	×	25,550
Benzo(a)pyrene	3.07E-06	= (	7.10E+00	×	7.30E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	)	÷ (	15	×	25,550
Benzo(b)fluoranthene	2.96E-07	= (	6.85E+00	×	7.30E-01	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	)	÷ (	15	×	25,550
Benzo(k)fluoranthene	8.34E-09	= (	1.93E+00	×	7.30E-02	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	)	÷ (	15	×	25,550
Indeno(1,2,3-cd)pyrene	2.04E-07	= (	4.72E+00	×	7.30E-01	×	1E-06	×	52	×	6	×	1	×	2800	×	0.2	×	1.30E-01	)	÷ (	15	×	25,550

**Notes:**

Derm - Risk – Dermal Risk

C<sub>soil</sub> – Soil Concentration

SF<sub>abs</sub> – Absorbed slope factor (SF<sub>o</sub> ÷ ABSgi)

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SA – Skin Surface Area

SSAF – Soil-to-skin Adherence Factor

ABSd – Dermal Soil Absorption Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

## Attachment D

**Table 11b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Child: Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(C_{\text{soil}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATn \times RfDabs)}$$

Equation Units	Derm - HQ unitless	= (	C <sub>soil</sub> mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSd unitless	) ÷ (	BW kg	×	ATn days	×	RfDabs (b) mg/kg-day	)
Aluminum	NA	= (	9.53E+03	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	NV	)
Arsenic	3.07E-03	= (	5.48E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	3.00E-02	) ÷ (	15	×	2,190	×	2.85E-04	)
Cadmium	2.88E-04	= (	1.35E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.00E-03	) ÷ (	15	×	2,190	×	2.50E-05	)
Iron	NA	= (	2.55E+04	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	NV	)
Lead	NA	= (	1.08E+02	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	NV	)
Manganese	NA	= (	3.47E+02	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	5.60E-03	)
Thallium	NA	= (	1.04E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	8.00E-04	)
Vanadium	NA	= (	3.66E+01	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	1.82E-04	)
Zinc	NA	= (	4.61E+02	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	NA	) ÷ (	15	×	2,190	×	3.00E-01	)
Benzo(a)anthracene	NA	= (	3.60E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV	)
Benzo(a)pyrene	NA	= (	7.10E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV	)
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1E-06	×	52	×	6	×	1	×	2,800	×	0.2	×	1.30E-01	) ÷ (	15	×	2,190	×	NV	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

C<sub>soil</sub> – Soil Concentration

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

ABSD – Dermal Soil Absorption Factor

BW – Body Weight

ATn – Averaging time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo × ABSgi)

NA – Not Applicable

NV – No toxicity value available for this pathway.

SSAF – Soil-to-skin Adherence Factor

## Attachment D

**Table 12a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Child: Inhalation of Soil -Derived Chemicals Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFI} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unithless	= (	Csoil mg/kg	×	SFI kg-day/mg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / VF m³/kg	+ 1 / PEF m³/kg	] ) ÷ (	BW kg	×	ATc days
Links Only	NA	= (	1	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Aluminum	NA	= (	9.53E+03	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Arsenic	1.23E-10	= (	5.48E+00	×	1.51E+01	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Cadmium	1.27E-11	= (	1.35E+00	×	6.30E+00	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Iron	NA	= (	2.55E+04	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Lead	NA	= (	1.08E+02	×	a	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Manganese	NA	= (	3.47E+02	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Thallium	NA	= (	1.04E+00	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Vanadium	NA	= (	3.66E+01	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Zinc	NA	= (	4.61E+02	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NA	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Benzo(a)anthracene	NA	= (	3.60E+00	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Benzo(a)pyrene	3.25E-11	= (	7.10E+00	×	3.08E+00	×	1.20	×	2	×	52	×	6	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	NV	×	1.20	×	2	×	52	×	6	×	[ 1 / NC	+ 1 / 1.32E+09	] ) ÷ (	15	×	25,550 )

Notes:

Inh - Risk – Inhalation Risk

Csoil – Soil Concentration

SFI – Inhalation Slope Factor

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

VF – Volatilization Factor

PEF – Particulate Emission Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 12b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Recreational Child: Inhalation of Soil-Derived Chemicals Pathway – Noncarcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Csoil} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times ([1/\text{VF}] + [1/\text{PEF}]))}{(\text{BW} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= (	Csoil mg/kg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / ]	VF m³/kg	+ 1 / ]	PEF m³/kg	] ÷ (	BW kg	×	ATn days	×	RfDi <sup>(b)</sup> mg/kg-day
Links Only	NA	= (	-	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	1.43E-03 )
Aluminum	1.16E-04	= (	9.53E+03	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	1.43E-03 )
Arsenic	NA	= (	5.48E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Cadmium	9.03E-08	= (	1.35E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	2.60E-04 )
Iron	NA	= (	2.55E+04	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Lead	NA	= (	1.08E+02	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	a )
Manganese	4.21E-04	= (	3.47E+02	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	1.43E-05 )
Thallium	NA	= (	1.04E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Vanadium	NA	= (	3.66E+01	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Zinc	NA	= (	4.61E+02	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NA	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Benzo(a)anthracene	NA	= (	3.60E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Benzo(a)pyrene	NA	= (	7.10E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Benzo(b)fluoranthene	NA	= (	6.85E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Benzo(k)fluoranthene	NA	= (	1.93E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )
Indeno(1,2,3-cd)pyrene	NA	= (	4.72E+00	×	1.2	×	2	×	52	×	6	×	[ 1 / ]	NC	+ 1 / ]	1.32E+09	] ÷ (	15	×	2,190	×	NV )

Notes:

Inh - Risk – Inhalation Hazard Quotient

Csoil – Soil Concentration

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

VF – Volatilization Factor

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

PEF – Particulate Emission Factor

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDi – Inhalation Reference Dose (subchronic)

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 12c**  
**Recreational Scenario: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^3}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>2</sup> /cm <sup>2</sup> )	VF (m <sup>3</sup> /kg)
Benzo(a)anthracene	73.32	3.14	NC	1.89E+08	2	1.38	1.00E-04	NC
Benzo(a)pyrene	73.32	3.14	NC	1.89E+08	2	1.38	1.00E-04	NC
Benzo(b)fluoranthene	73.32	3.14	NC	1.89E+08	2	1.38	1.00E-04	NC
Benzo(k)fluoranthene	73.32	3.14	NC	1.89E+08	2	1.38	1.00E-04	NC
Indeno(1,2,3-cd)pyrene	73.32	3.14	NC	1.89E+08	2	1.38	1.00E-04	NC

Notes: Default values are as presented in Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002).

VF – Volatilization Factor (m<sup>3</sup>/kg) (calculated)

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source  
(g/m<sup>2</sup>-s)/(kg/m<sup>3</sup>)(Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T – Exposure interval (s)

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated; PAHs are not considered volatile chemicals

## Attachment D

**Table 12d**  
**Recreational Scenario: Apparent Diffusivity Calculations**

Equation:

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H')}$$

Chemical	VOC?	$\theta_a$	$D_i$	$H'$	$\theta_w$	$D_w$	$\eta$	$\rho_b$	$\rho_s$	$K_d$	$D_A$
Units		(Lair / Lsoil )	(cm <sup>2</sup> /s)	unitless	(Lwater / Lsoil )	(cm <sup>2</sup> /s)	(Lpore / Lsoil )	(g/cm <sup>3</sup> )	(g/cm <sup>3</sup> )	(cm <sup>3</sup> /g )	(cm <sup>2</sup> /s)
Benzo(a)anthracene	No	3.29E-01	5.10E-02	4.91E-04	0.15	9.00E-06	4.79E-01	1.38	2.65	1.39E+03	NC
Benzo(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Benzo(b)fluoranthene	No	3.29E-01	2.26E-02	2.69E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.82E+03	NC
Benzo(k)fluoranthene	No	3.29E-01	2.26E-02	2.39E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Indeno(1,2,3-cd)pyrene	No	3.29E-01	1.90E-02	1.42E-05	0.15	5.66E-06	4.79E-01	1.38	2.65	1.61E+04	NC

Notes:

$D_A$  – apparent diffusivity

$\theta_a$  – air-filled soil porosity

$D_i$  – diffusivity in air

$H'$  – dimensionless Henry's Law constant

$\theta_w$  – water-filled soil porosity

$D_w$  – diffusivity in water

$\eta$  – total soil porosity

$\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User's Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).

$\rho_s$  – soil particle density

$K_d$  – soil-water partition coefficient, where:

$$K_d = K_{oc} \times f_{oc}$$

$K_{oc}$  – soil organic carbon partition coefficient (cm<sup>3</sup> /g)

$f_{oc}$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)

VOC? – Volatile organic compounds; If no, an apparent diffusivity was not calculated.

NV – no value available

NC – not calculated

## Attachment D

**Table 13a**  
**Risk Calculations**  
**Adult Swimmer: Incidental Ingestion of Sediment Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Csediment} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ET} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Ing - Risk unitless	= (	Csediment mg/kg	×	SFo kg-day/mg	×	CF kg/mg	×	EF events/year	×	ET hour/event	×	ED years	×	SIR mg/hour	×	FI unitless	) ÷ (	BW kg	×	ATc days
Iron	NA	= (	2.70E+04	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Manganese	NA	= (	3.00E+02	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Vanadium	NA	= (	9.70E+00	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
1-Methylnaphthalene	NA	= (	1.90E+01	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
2-Methylnaphthalene	NA	= (	5.46E+02	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Acenaphthene	NA	= (	1.85E+02	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Benzo(a)anthracene	1.63E-09	= (	3.96E+01	×	7.30E-01	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Benzo(a)pyrene	1.18E-08	= (	2.86E+01	×	7.30E+00	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Benzo(b)fluoranthene	6.19E-10	= (	1.50E+01	×	7.30E-01	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Benzo(k)fluoranthene	7.87E-11	= (	1.91E+01	×	7.30E-02	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Chrysene	1.45E-11	= (	3.53E+01	×	7.30E-03	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Dibeno(a,h)anthracene	7.82E-10	= (	1.90E+00	×	7.30E+00	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Fluoranthene	NA	= (	8.65E+01	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Fluorene	NA	= (	1.13E+02	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Indeno(1,2,3-cd)pyrene	2.18E-10	= (	5.30E+00	×	7.30E-01	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Naphthalene	NA	= (	5.73E+02	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Pyrene	NA	= (	1.10E+02	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Methylene chloride	5.49E-12	= (	1.30E+01	×	7.50E-03	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )
Xylenes (total)	NA	= (	1.03E+01	×	NV	×	0.000001	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	25,550 )

**Notes:**

Ing - Risk – Ingestion risk

Csediment – Concentration in sediment

SFo – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Sediment Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 13b**  
**Risk Calculations**  
**Adult Swimmer: Incidental Ingestion of Sediment Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csediment} \times \text{CF} \times \text{EF} \times \text{ET} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csediment mg/kg	×	CF kg/mg	×	EF event/year	×	ET hours/event	×	ED years	×	SIR mg/hour	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day	)
Iron	1.18E-05	= (	2.70E+04	×	1E-06	×	12	×	1	×	30	×	0.280	×	1	) ÷ (	70	×	10,950	×	3.0E-01	)
Manganese	8.45E-07	= (	3.00E+02	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.7E-02	)
Vanadium	1.28E-06	= (	9.70E+00	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	1.0E-03	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
2-Methylnaphthalene	1.80E-05	= (	5.46E+02	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.0E-03	)
Acenaphthene	4.05E-07	= (	1.85E+02	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	6.0E-02	)
Benzo(a)anthracene	NA	= (	3.96E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(a)pyrene	NA	= (	2.86E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(b)fluoranthene	NA	= (	1.50E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.91E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Chrysene	NA	= (	3.53E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Dibenzo(a,h)anthracene	NA	= (	1.90E+00	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Fluoranthene	2.84E-07	= (	8.65E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.0E-02	)
Fluorene	3.70E-07	= (	1.13E+02	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.0E-02	)
Indeno(1,2,3-cd)pyrene	NA	= (	5.30E+00	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Naphthalene	3.77E-06	= (	5.73E+02	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	2.0E-02	)
Pyrene	4.8E-07	= (	1.10E+02	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	3.0E-02	)
Methylene chloride	2.8E-08	= (	1.30E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	6.0E-02	)
Xylenes (total)	6.8E-09	= (	1.03E+01	×	1E-06	×	12	×	1	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	2.0E-01	)

**Notes:**

Ing - HQ – Ingestion Hazard  
 Csediment – Concentration in sediment  
 CF – Unit Conversion Factor  
 EF – Exposure Frequency  
 ED – Exposure Duration  
 SIR – Sediment Ingestion Rate  
 ET – Exposure Time

FI – Fraction Ingested from Contaminated Source  
 BW – Body Weight  
 ATn – Averaging Time for Noncarcinogens  
 RfDo – Oral reference dose  
 NV – No toxicity value available for this pathway.  
 NA – Not Applicable

## Attachment D

**Table 14a**  
**Risk Calculations**  
**Adult Swimmer: Incidental Dermal Contact with Sediment Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csediment} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSD})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Derm - Risk	= (	Csediment	×	SFabs	×	CF	×	EF	×	ED	×	EV	×	SA	×	SSAF	×	ABSD	) ÷ (	BW	×	ATc	)
	unitless		mg/kg		kg-day/mg		kg/mg		days/year		years		events/day		cm <sup>2</sup>		mg/cm <sup>2</sup> -event		unitless		kg		days	
Iron	NA	= (	2.70E+04	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
Manganese	NA	= (	3.00E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
Vanadium	NA	= (	9.70E+00	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
2-Methylnaphthalene	NA	= (	5.46E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.00E-01	) ÷ (	70	×	25,550	)
Acenaphthene	NA	= (	1.85E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(a)anthracene	4.29E-06	= (	3.96E+01	×	7.30E-01	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(a)pyrene	3.10E-05	= (	2.86E+01	×	7.30E+00	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(b)fluoranthene	1.63E-06	= (	1.50E+01	×	7.30E-01	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(k)fluoranthene	2.07E-07	= (	1.91E+01	×	7.30E-02	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Chrysene	3.83E-08	= (	3.53E+01	×	7.30E-03	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Dibenzo(a,h)anthracene	2.06E-06	= (	1.90E+00	×	7.30E+00	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Fluoranthene	NA	= (	8.65E+01	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Fluorene	NA	= (	1.13E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Indeno(1,2,3-cd)pyrene	5.74E-07	= (	5.30E+00	×	7.30E-01	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Naphthalene	NA	= (	5.73E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Pyrene	NA	= (	1.10E+02	×	NV	×	1E-06	×	12		30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Methylene chloride	NA	= (	1.30E+01	×	7.50E-03	×	1E-06	×	12		30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
Xylenes (total)	NA	= (	1.03E+01	×	NV	×	1E-06	×	12		30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)

**Notes:**

Derm - Risk – Dermal Risk

Csediment – Concentration in Sediment

SFabs – Absorbed slope factor (SFo ÷ ABSgi)

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

SSAF – Sediment-to-skin Adherence Factor

ABSD – Dermal Sediment Absorption Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

## Attachment D

**Table 14b**  
**Risk Calculations**

**Adult Swimmer: Incidental Dermal Contact with Sediment Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csediment} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ unitless	Csediment mg/kg	CF kg/mg	EF days/year	ED years	EV events/day	SA cm <sup>2</sup>	SSAF mg/cm <sup>2</sup> -event	ABSd unitless	) ÷ (	BW kg	ATn days	× RfDabs mg/kg-day	)
Iron	NA	= ( 2.70E+04	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× NA	) ÷ ( 70	× 10,950	× NV	)
Manganese	NA	= ( 3.00E+02	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× NA	) ÷ ( 70	× 10,950	× 1.87E-03	)
Vanadium	NA	= ( 9.70E+00	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× NA	) ÷ ( 70	× 10,950	× 2.60E-05	)
1-Methylnaphthalene	NA	= ( 1.90E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
2-Methylnaphthalene	3.64E-02	= ( 5.46E+02	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.00E-01	) ÷ ( 70	× 10,950	× 4.00E-03	)
Acenaphthene	1.07E-03	= ( 1.85E+02	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× 6.00E-02	)
Benzo(a)anthracene	NA	= ( 3.96E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Benzo(a)pyrene	NA	= ( 2.86E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Benzo(b)fluoranthene	NA	= ( 1.50E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Benzo(k)fluoranthene	NA	= ( 1.91E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Chrysene	NA	= ( 3.53E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Dibenzo(a,h)anthracene	NA	= ( 1.90E+00	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Fluoranthene	7.49E-04	= ( 8.65E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× 4.00E-02	)
Fluorene	9.75E-04	= ( 1.13E+02	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× 4.00E-02	)
Indeno(1,2,3-cd)pyrene	NA	= ( 5.30E+00	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)
Naphthalene	9.92E-03	= ( 5.73E+02	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× 2.00E-02	)
Pyrene	3.81E-05	= ( 1.10E+02	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× 1.30E-01	) ÷ ( 70	× 10,950	× 3.00E-02	)
Methylene chloride	NA	= ( 1.30E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× NA	) ÷ ( 70	× 10,950	× 6.00E-02	)
Xylenes (total)	NA	= ( 1.03E+01	× 1E-06	× 12	× 30	× 1	× 5,672	×	1	× NA	) ÷ ( 70	× 10,950	× 2.00E-01	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

Csediment – Concentration in Sediment

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

ABSd – Dermal Sediment Absorption Factor

BW – Body Weight

ATn – Averaging Time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo × ABSgi)

NA – Not Applicable

NV – No toxicity value available for this pathway.

SSAF – Sediment-to-skin Adherence Factor

## Attachment D

**Table 15a**  
**Risk Calculations**  
**Adolescent Swimmer: Incidental Ingestion of Sediment Pathway – Carcinogenic Effects**

Ing-Risk = $\frac{(\text{Csediment} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ET} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$																					
Equation Units	Ing - Risk unitless	$\text{Csediment}$ mg/kg	$\times$	$\text{SFo}$ kg-day/mg	$\times$	$\text{CF}$ kg/mg	$\times$	$\text{EF}$ event/year	$\times$	$\text{ET}$ hours/event	$\times$	$\text{ED}$ years	$\times$	$\text{SIR}$ mg/hour	$\times$	$\text{FI}$ unitless	) $\div$ (	$\text{BW}$ kg	$\times$	$\text{ATc}$ days	
Iron	NA	= (	2.70E+04	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Manganese	NA	= (	3.00E+02	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Vanadium	NA	= (	9.70E+00	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
1-Methylnaphthalene	NA	= (	1.90E+01	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
2-Methylnaphthalene	NA	= (	5.46E+02	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Acenaphthene	NA	= (	1.85E+02	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.00	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Benz(a)anthracene	9.70E-10	= (	3.96E+01	$\times$	7.30E-01	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Benz(a)pyrene	7.01E-09	= (	2.86E+01	$\times$	7.30E+00	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Benz(b)fluoranthene	3.69E-10	= (	1.50E+01	$\times$	7.30E-01	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Benz(k)fluoranthene	4.69E-11	= (	1.91E+01	$\times$	7.30E-02	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Chrysene	8.66E-12	= (	3.53E+01	$\times$	7.30E-03	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Dibenzo(a,h)anthracene	4.66E-10	= (	1.90E+00	$\times$	7.30E+00	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Fluoranthene	NA	= (	8.65E+01	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Fluorene	NA	= (	1.13E+02	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Indeno(1,2,3-cd)pyrene	1.30E-10	= (	5.30E+00	$\times$	7.30E-01	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Naphthalene	NA	= (	5.73E+02	$\times$	NV	$\times$	1.E-06	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Pyrene	NA	= (	1.10E+02	$\times$	NV	$\times$	0.000001	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Methylene chloride	3.27E-12	= (	1.30E+01	$\times$	7.50E-03	$\times$	0.000001	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )
Xylenes (total)	NA	= (	1.03E+01	$\times$	NV	$\times$	0.000001	$\times$	12	$\times$	1	$\times$	12	$\times$	0.28	$\times$	1	) $\div$ (	47	$\times$	25,550 )

**Notes:**

Ing - Risk – Ingestion risk  
Csediment – Concentration in sediment  
SFo – Oral Slope Factor  
CF – Unit Conversion Factor  
EF – Exposure Frequency  
ET – Exposure Time  
ED – Exposure Duration

SIR – Sediment Ingestion Rate  
FI – Fraction Ingested from Contaminated Source  
BW – Body Weight  
ATc – Averaging Time for Carcinogens  
NV – No toxicity value available for this pathway.  
NA – Not Applicable

## Attachment D

**Table 15b**  
**Risk Calculations**  
**Adolescent Swimmer: Incidental Ingestion of Sediment Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csediment} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csediment mg/kg	×	CF kg/mg	×	EF events/year	×	ED years	×	ET hours/event	×	SIR mg/hour	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day	)
Iron	1.76E-05	= (	2.70E+04	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	3.0E-01	)
Manganese	1.26E-06	= (	3.00E+02	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	4.7E-02	)
Vanadium	1.90E-06	= (	9.70E+00	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	1.0E-03	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
2-Methylnaphthalene	2.67E-05	= (	5.46E+02	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	4.0E-03	)
Acenaphthene	0.00E+00	= (	1.85E+02	×	1E-06	×	12	×	12	×	1	×	0.00	×	1.00	) ÷ (	47	×	4,380	×	6.0E-02	)
Benzo(a)anthracene	NA	= (	3.96E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Benzo(a)pyrene	NA	= (	2.86E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Benzo(b)fluoranthene	NA	= (	1.50E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.91E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Chrysene	NA	= (	3.53E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Dibenzo(a,h)anthracene	NA	= (	1.90E+00	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Fluoranthene	4.24E-07	= (	8.65E+01	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	4.0E-02	)
Fluorene	5.51E-07	= (	1.13E+02	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	4.0E-02	)
Indeno(1,2,3-cd)pyrene	NA	= (	5.30E+00	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	NV	)
Naphthalene	5.61E-06	= (	5.73E+02	×	1E-06	×	12	×	12	×	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	2.0E-02	)
Pyrene	7.2E-07	= (	1.10E+02	×	1E-06	×	12	×	12	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	3.0E-02	)	
Methylene chloride	4.2E-08	= (	1.30E+01	×	1E-06	×	12	×	12	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	6.0E-02	)	
Xylenes (total)	1.0E-08	= (	1.03E+01	×	1E-06	×	12	×	12	1	×	0.28	×	1.00	) ÷ (	47	×	4,380	×	2.0E-01	)	

Notes:

Ing - HQ – Ingestion Hazard

Csediment – Concentration in sediment

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Sediment Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose

**Attachment D**

**Table 16a  
Risk Calculations  
Adolescent Swimmer: Incidental Dermal Contact with Sediment Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(C_{\text{sediment}} \times SF_{\text{abs}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATc)}$$

Equation Units	Derm - Risk unitless	$C_{\text{sediment}}$ mg/kg	$SF_{\text{abs}}$ kg-day/mg	$CF$ kg/mg	$EF$ days/year	$ED$ years	$EV$ events/day	$SA$ cm <sup>2</sup>	$SSAF$ mg/cm <sup>2</sup> -event	$ABSd$ unitless	$) \div ($	$BW$ kg	$ATc$ days
Iron	NA	= ( 2.70E+04	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x NA	) ÷ ( 47	x 25,550	)
Manganese	NA	= ( 3.00E+02	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x NA	) ÷ ( 47	x 25,550	)
Vanadium	NA	= ( 9.70E+00	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x NA	) ÷ ( 47	x 25,550	)
1-Methylnaphthalene	NA	= ( 1.90E+01	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
2-Methylnaphthalene	NA	= ( 5.46E+02	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.00E-01	) ÷ ( 47	x 25,550	)
Acenaphthene	NA	= ( 1.85E+02	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Benzo(a)anthracene	1.82E-06	= ( 3.96E+01	x 7.30E-01	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Benzo(a)pyrene	1.32E-05	= ( 2.86E+01	x 7.30E+00	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Benzo(b)fluoranthene	6.93E-07	= ( 1.50E+01	x 7.30E-01	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Benzo(k)fluoranthene	8.80E-08	= ( 1.91E+01	x 7.30E-02	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Chrysene	1.63E-08	= ( 3.53E+01	x 7.30E-03	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Dibenzo(a,h)anthracene	8.75E-07	= ( 1.90E+00	x 7.30E+00	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Fluoranthene	NA	= ( 8.65E+01	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Fluorene	NA	= ( 1.13E+02	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Indeno(1,2,3-cd)pyrene	2.44E-07	= ( 5.30E+00	x 7.30E-01	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Naphthalene	NA	= ( 5.73E+02	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Pyrene	NA	= ( 1.10E+02	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x 1.30E-01	) ÷ ( 47	x 25,550	)
Methylene chloride	NA	= ( 1.30E+01	x 7.50E-03	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x NA	) ÷ ( 47	x 25,550	)
Xylenes (total)	NA	= ( 1.03E+01	x NV	x 1E-06	x 12	x 12	x 1	x 4,046	x 1	x NA	) ÷ ( 47	x 25,550	)

**Notes:**

Derm - Risk – Dermal Risk

Csediment – Concentration in sediment

SFabs – Absorbed slope factor (SF<sub>o</sub> ÷ ABS<sub>gi</sub>)

CF – Conversion factor

EF – Exposure Frequency

ET – Exposure Time

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

SSAF – Sediment-to-skin Adherence Factor

ABSd – Dermal Sediment Absorption Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

## Attachment D

**Table 16b**  
**Risk Calculations**  
**Adolescent Swimmer: Incidental Dermal Contact with Sediment Pathway – Noncarcinogenic Effects**

Derm - HQ = 
$$\frac{(Csediment \times EF \times CF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATn \times RfDabs)}$$

Equation Units	Derm - HQ	=	(	Csediment	$\times$	CF	$\times$	EF	$\times$	ED	$\times$	EV	$\times$	SA	$\times$	SSAF	$\times$	ABSd	)	$\div$	(	BW	$\times$	ATn	$\times$	RfDabs	)
			unitless	mg/kg	kg/mg	days/year	years	events/day	cm <sup>2</sup>	mg/cm <sup>2</sup> -event	unitless	kg	days	mg/kg-day													
Iron	NA	=	(	2.70E+04	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	NA	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Manganese	NA	=	(	3.00E+02	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	NA	)	$\div$	(	47	$\times$	4,380	$\times$	1.87E-03	)
Vanadium	NA	=	(	9.70E+00	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	NA	)	$\div$	(	47	$\times$	4,380	$\times$	2.60E-05	)
1-Methylnaphthalene	NA	=	(	1.90E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
2-Methylnaphthalene	3.86E-02	=	(	5.46E+02	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.00E-01	)	$\div$	(	47	$\times$	4,380	$\times$	4.00E-03	)
Acenaphthene	1.13E-03	=	(	1.85E+02	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	6.00E-02	)
Benzo(a)anthracene	NA	=	(	3.96E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Benzo(a)pyrene	NA	=	(	2.86E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Benzo(b)fluoranthene	NA	=	(	1.50E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Benzo(k)fluoranthene	NA	=	(	1.91E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Chrysene	NA	=	(	3.53E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Dibenz(a,h)anthracene	NA	=	(	1.90E+00	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Fluoranthene	7.96E-04	=	(	8.65E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	4.00E-02	)
Fluorene	1.04E-03	=	(	1.13E+02	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	4.00E-02	)
Indeno(1,2,3-cd)pyrene	NA	=	(	5.30E+00	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	NV	)
Naphthalene	1.05E-02	=	(	5.73E+02	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	2.00E-02	)
Pyrene	4.05E-05	=	(	1.10E+02	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	1.30E-01	)	$\div$	(	47	$\times$	4,380	$\times$	3.00E-02	)
Methylene chloride	NA	=	(	1.30E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	NA	)	$\div$	(	47	$\times$	4,380	$\times$	6.00E-02	)
Xylenes (total)	NA	=	(	1.03E+01	$\times$	1E-06	$\times$	12	$\times$	12	$\times$	1	$\times$	4,046	$\times$	1	$\times$	NA	)	$\div$	(	47	$\times$	4,380	$\times$	2.00E-01	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

Csediment – Concentration in sediment

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

SSAF – Sediment-to-skin Adherence Factor

ABSD – Dermal Sediment Absorption Factor

BW – Body Weight

ATn – Averaging Time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo  $\times$  ABSgi)

**Attachment D**

**Table 17a**  
**Risk Calculations**  
**Adult Wader: Incidental Ingestion of Sediment Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Csediment} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ET} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Ing - Risk unitless	= (	Csediment mg/kg	×	SFo kg-day/mg	×	CF kg/mg	×	EF events/year	×	ET hour/event	×	ED years	×	SIR mg/hour	×	FI unitless	) ÷ (	BW kg	×	ATc days	)
Iron	NA	= (	2.70E+04	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Manganese	NA	= (	3.00E+02	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Vanadium	NA	= (	9.70E+00	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
2-Methylnaphthalene	NA	= (	5.46E+02	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Acenaphthene	NA	= (	1.85E+02	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Benzo(a)anthracene	3.26E-09	= (	3.96E+01	×	7.30E-01	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Benzo(a)pyrene	2.35E-08	= (	2.86E+01	×	7.30E+00	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Benzo(b)fluoranthene	1.24E-09	= (	1.50E+01	×	7.30E-01	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Benzo(k)fluoranthene	1.57E-10	= (	1.91E+01	×	7.30E-02	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Chrysene	2.91E-11	= (	3.53E+01	×	7.30E-03	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Dibenzo(a,h)anthracene	1.56E-09	= (	1.90E+00	×	7.30E+00	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Fluoranthene	NA	= (	8.65E+01	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Fluorene	NA	= (	1.13E+02	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Indeno(1,2,3-cd)pyrene	4.36E-10	= (	5.30E+00	×	7.30E-01	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Naphthalene	NA	= (	5.73E+02	×	NV	×	1.E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Pyrene	NA	= (	1.10E+02	×	NV	×	0.000001	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Methylene chloride	5.49E-12	= (	1.30E+01	×	7.50E-03	×	0.000001	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)
Xylenes (total)	NA	= (	1.03E+01	×	NV	×	0.000001	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	25,550	)

**Notes:**

Ing - Risk – Ingestion risk

Csediment – Concentration in sediment

SFo – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Sediment Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 17b**  
**Risk Calculations**  
**Adult Wader: Incidental Ingestion of Sediment Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csediment} \times \text{CF} \times \text{EF} \times \text{ET} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csediment mg/kg	×	CF kg/mg	×	EF days/year	×	ET hours/day	×	ED years	×	SIR mg/hour	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day	)
Iron	2.37E-05	= (	2.70E+04	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	3.0E-01	)
Manganese	8.45E-07	= (	3.00E+02	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.7E-02	)
Vanadium	1.28E-06	= (	9.70E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	1.0E-03	)
1-Methylphenanthrene	NA	= (	1.00E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
2-Methylnaphthalene	1.80E-05	= (	5.46E+02	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.0E-03	)
Acenaphthene	2.19E-09	= (	1.00E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	6.0E-02	)
Benzo(a)anthracene	NA	= (	3.96E+01	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(a)pyrene	NA	= (	2.86E+01	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(b)fluoranthene	NA	= (	1.50E+01	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.91E+01	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Chrysene	NA	= (	1.00E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Dibenz(a,h)anthracene	NA	= (	1.00E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Fluoranthene	3.29E-09	= (	1.00E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.0E-02	)
Fluorene	3.29E-09	= (	1.00E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	4.0E-02	)
Indeno(1,2,3-cd)pyrene	NA	= (	5.30E+00	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	NV	)
Naphthalene	3.77E-06	= (	5.73E+02	×	1E-06	×	12	×	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	2.0E-02	)
Pyrene	4.8E-07	= (	1.10E+02	×	1E-06	×	12	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	3.0E-02	)	
Methylene chloride	2.8E-08	= (	1.30E+01	×	1E-06	×	12	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	6.0E-02	)	
Xylenes (total)	6.8E-09	= (	1.03E+01	×	1E-06	×	12	2	×	30	×	0.28	×	1	) ÷ (	70	×	10,950	×	2.0E-01	)	

**Notes:**

Ing - HQ – Ingestion Hazard

Csediment – Concentration in sediment

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Sediment Ingestion Rate

ET – Exposure Time

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 18a**  
**Risk Calculations**  
**Adult Wader: Incidental Dermal Contact with Sediment Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csediment} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSD})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Derm - Risk	= (	Csediment	×	SFabs	×	CF	×	EF	×	ED	×	EV	×	SA	×	SSAF	×	ABSD	) ÷ (	BW	×	ATc	)
	unitless		mg/kg		kg-day/mg		kg/mg		days/year		years		events/day		cm <sup>2</sup>		mg/cm <sup>2</sup> -event		unitless		kg		days	
Iron	NA	= (	2.70E+04	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
Manganese	NA	= (	3.00E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
Vanadium	NA	= (	9.70E+00	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
2-Methylnaphthalene	NA	= (	5.46E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.00E-01	) ÷ (	70	×	25,550	)
Acenaphthene	NA	= (	1.85E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(a)anthracene	4.29E-06	= (	3.96E+01	×	7.30E-01	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(a)pyrene	3.10E-05	= (	2.86E+01	×	7.30E+00	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(b)fluoranthene	1.63E-06	= (	1.50E+01	×	7.30E-01	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(k)fluoranthene	2.07E-07	= (	1.91E+01	×	7.30E-02	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Chrysene	3.83E-08	= (	3.53E+01	×	7.30E-03	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Dibenzo(a,h)anthracene	2.06E-06	= (	1.90E+00	×	7.30E+00	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Fluoranthene	NA	= (	8.65E+01	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Fluorene	NA	= (	1.13E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Indeno(1,2,3-cd)pyrene	5.74E-07	= (	5.30E+00	×	7.30E-01	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Naphthalene	NA	= (	5.73E+02	×	NV	×	1E-06	×	12	×	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)
Pyrene	NA	= (	1.10E+02	×	NV	×	1E-06	×	12	30	×	1	×	5,672	×	1	×	1.30E-01	) ÷ (	70	×	25,550	)	
Methylene chloride	NA	= (	1.30E+01	×	7.50E-03	×	1E-06	×	12	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)	
Xylenes (total)	NA	= (	1.03E+01	×	NV	×	1E-06	×	12	30	×	1	×	5,672	×	1	×	NA	) ÷ (	70	×	25,550	)	

**Notes:**

Derm - Risk – Dermal Risk

Csediment – Concentration in Sediment

SFabs – Absorbed slope factor (SFo ÷ ABSgi)

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

SSAF – Sediment-to-skin Adherence Factor

ABSD – Dermal Sediment Absorption Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

## Attachment D

**Table 18b**  
**Risk Calculations**

**Adult Wader: Incidental Dermal Contact with Sediment Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csediment} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ unitless	Csediment mg/kg	CF kg/mg	EF days/year	ED years	EV events/day	SA cm <sup>2</sup>	SSAF mg/cm <sup>2</sup> -event	ABSd unitless	) ÷ (	BW kg	ATn days	× RfDabs mg/kg-day	)
Iron	NA	= ( 2.70E+04	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× NA	) ÷ ( 70	× 10,950	× NV	)	
Manganese	NA	= ( 3.00E+02	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× NA	) ÷ ( 70	× 10,950	× 1.87E-03	)	
Vanadium	NA	= ( 9.70E+00	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× NA	) ÷ ( 70	× 10,950	× 2.60E-05	)	
1-Methylnaphthalene	NA	= ( 1.90E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
2-Methylnaphthalene	3.64E-02	= ( 5.46E+02	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.00E-01	) ÷ ( 70	× 10,950	× 4.00E-03	)	
Acenaphthene	1.07E-03	= ( 1.85E+02	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× 6.00E-02	)	
Benzo(a)anthracene	NA	= ( 3.96E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Benzo(a)pyrene	NA	= ( 2.86E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Benzo(b)fluoranthene	NA	= ( 1.50E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Benzo(k)fluoranthene	NA	= ( 1.91E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Chrysene	NA	= ( 3.53E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Dibenzo(a,h)anthracene	NA	= ( 1.90E+00	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Fluoranthene	7.49E-04	= ( 8.65E+01	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× 4.00E-02	)	
Fluorene	9.75E-04	= ( 1.13E+02	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× 4.00E-02	)	
Indeno(1,2,3-cd)pyrene	NA	= ( 5.30E+00	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× NV	)	
Naphthalene	9.92E-03	= ( 5.73E+02	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× 2.00E-02	)	
Pyrene	3.46E-07	= ( 1	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× 1.30E-01	) ÷ ( 70	× 10,950	× 3.00E-02	)	
Methylene chloride	NA	= ( 1	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× NA	) ÷ ( 70	× 10,950	× 6.00E-02	)	
Xylenes (total)	NA	= ( 1	× 1E-06	× 12	× 30	× 1	× 5,672	× 1	× NA	) ÷ ( 70	× 10,950	× 2.00E-01	)	

**Notes:**

Derm - HQ – Dermal Hazard Quotient

Csediment – Concentration in Sediment

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

ABSd – Dermal Sediment Absorption Factor

BW – Body Weight

ATn – Averaging Time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo × ABSgi)

NA – Not Applicable

NV – No toxicity value available for this pathway.

SSAF – Sediment-to-skin Adherence Factor

## Attachment D

**Table 19a**  
**Risk Calculations**  
**Adolescent Wader: Incidental Ingestion of Sediment Pathway – Carcinogenic Effects**

Ing-Risk = $\frac{(\text{Csediment} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ET} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$															
Equation Units	Ing - Risk unitless	Csediment mg/kg	SFo kg-day/mg	CF kg/mg	EF event/year	ET hours/event	ED years	SIR mg/hour	FI unitless	) ÷ (	BW kg	ATc days	)		
Iron	NA	= ( 2.70E+04	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Manganese	NA	= ( 3.00E+02	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Vanadium	NA	= ( 9.70E+00	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
1-Methylnaphthalene	NA	= ( 1.90E+01	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
2-Methylnaphthalene	NA	= ( 5.46E+02	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Acenaphthene	NA	= ( 1.85E+02	× NV	× 1.E-06	× 12	× 2	× 12	× 0.00	× 1	) ÷ ( 47	× 25,550	)			
Benzo(a)anthracene	1.94E-09	= ( 3.96E+01	× 7.30E-01	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Benzo(a)pyrene	1.40E-08	= ( 2.86E+01	× 7.30E+00	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Benzo(b)fluoranthene	7.38E-10	= ( 1.50E+01	× 7.30E-01	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Benzo(g,h,i)perylene	NA	= ( 1.00E+00	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Benzo(k)fluoranthene	9.37E-11	= ( 1.91E+01	× 7.30E-02	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Chrysene	1.73E-11	= ( 3.53E+01	× 7.30E-03	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Dibenzo(a,h)anthracene	9.31E-10	= ( 1.90E+00	× 7.30E+00	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Fluoranthene	NA	= ( 8.65E+01	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Fluorene	NA	= ( 1.13E+02	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Indeno(1,2,3-cd)pyrene	2.60E-10	= ( 5.30E+00	× 7.30E-01	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Naphthalene	NA	= ( 5.73E+02	× NV	× 1.E-06	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Pyrene	NA	= ( 1.10E+02	× NV	× 0.000001	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Methylene chloride	3.27E-12	= ( 1.30E+01	× 7.50E-03	× 0.000001	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			
Xylenes (total)	NA	= ( 1.03E+01	× NV	× 0.000001	× 12	× 2	× 12	× 0.28	× 1	) ÷ ( 47	× 25,550	)			

**Notes:**

Ing - Risk – Ingestion risk

Csediment – Concentration in sediment

SFo – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ET – Exposure Time

ED – Exposure Duration

SIR – Sediment Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 19b**  
**Risk Calculations**  
**Adolescent Wader: Incidental Ingestion of Sediment Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csediment} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csediment mg/kg	×	CF kg/mg	×	EF events/year	×	ED years	×	ET hours/event	×	SIR mg/hour	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day	)
Iron	3.53E-05	= (	2.70E+04	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	3.0E-01	)
Manganese	2.52E-06	= (	3.00E+02	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	4.7E-02	)
Vanadium	3.80E-06	= (	9.70E+00	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	1.0E-03	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
2-Methylnaphthalene	5.35E-05	= (	5.46E+02	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	4.0E-03	)
Acenaphthene	0.00E+00	= (	1.85E+02	×	1E-06	×	12	×	12	×	2	×	0.00	×	1	) ÷ (	47	×	4,380	×	6.0E-02	)
Benzo(a)anthracene	NA	= (	3.96E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Benzo(a)pyrene	NA	= (	2.86E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Benzo(b)fluoranthene	NA	= (	1.50E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Benzo(g,h,i)perylene	NA	= (	1.00E+00	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Benzo(k)fluoranthene	NA	= (	1.91E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Chrysene	NA	= (	3.53E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Dibenzo(a,h)anthracene	NA	= (	1.90E+00	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Fluoranthene	8.47E-07	= (	8.65E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	4.0E-02	)
Fluorene	1.10E-06	= (	1.13E+02	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	4.0E-02	)
Indeno(1,2,3-cd)pyrene	NA	= (	5.30E+00	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	NV	)
Naphthalene	1.12E-05	= (	5.73E+02	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	2.0E-02	)
Pyrene	7.2E-07	= (	1.10E+02	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	3.0E-02	)
Methylene chloride	4.2E-08	= (	1.30E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	6.0E-02	)
Xylenes (total)	1.0E-08	= (	1.03E+01	×	1E-06	×	12	×	12	×	2	×	0.28	×	1	) ÷ (	47	×	4,380	×	2.0E-01	)

Notes:

Ing - HQ – Ingestion Hazard  
 Csediment – Concentration in sediment  
 CF – Unit Conversion Factor  
 EF – Exposure Frequency  
 ED – Exposure Duration

SIR – Sediment Ingestion Rate  
 FI – Fraction Ingested from Contaminated Source  
 BW – Body Weight  
 ATn – Averaging Time for Noncarcinogens  
 RfDo – Oral reference dose

**Attachment D**

**Table 20a**  
**Risk Calculations**  
**Adolescent Wader: Incidental Dermal Contact with Sediment Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(C_{\text{sediment}} \times SF_{\text{abs}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATc)}$$

Equation Units	Derm - Risk	= (	C <sub>sediment</sub>	×	SF <sub>abs</sub>	×	CF	×	EF	×	ED	×	EV	×	SA	×	SSAF	×	ABSd	) ÷ (	BW	×	ATc	)
			unitless	mg/kg	kg-day/mg	kg/mg	days/year	years	events/day	cm <sup>2</sup>	mg/cm <sup>2</sup> -event	unitless	kg	days										
Iron	NA	= (	2.70E+04	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	) ÷ (	47	×	25,550	)
Manganese	NA	= (	3.00E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	) ÷ (	47	×	25,550	)
Vanadium	NA	= (	9.70E+00	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	) ÷ (	47	×	25,550	)
1-Methylnaphthalene	NA	= (	1.90E+01	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
2-Methylnaphthalene	NA	= (	5.46E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.00E-01	) ÷ (	47	×	25,550	)
Acenaphthene	NA	= (	1.85E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Benzo(a)anthracene	1.82E-06	= (	3.96E+01	×	7.30E-01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Benzo(a)pyrene	1.32E-05	= (	2.86E+01	×	7.30E+00	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Benzo(b)fluoranthene	6.93E-07	= (	1.50E+01	×	7.30E-01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Benzo(g,h,i)perylene	NA	= (	1.00E+00	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Benzo(k)fluoranthene	8.80E-08	= (	1.91E+01	×	7.30E-02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Chrysene	1.63E-08	= (	3.53E+01	×	7.30E-03	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Dibenzo(a,h)anthracene	8.75E-07	= (	1.90E+00	×	7.30E+00	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Fluoranthene	NA	= (	8.65E+01	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Fluorene	NA	= (	1.13E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Indeno(1,2,3-cd)pyrene	2.44E-07	= (	5.30E+00	×	7.30E-01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Naphthalene	NA	= (	5.73E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Pyrene	NA	= (	1.10E+02	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	) ÷ (	47	×	25,550	)
Methylene chloride	NA	= (	1.30E+01	×	7.50E-03	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	) ÷ (	47	×	25,550	)
Xylenes (total)	NA	= (	1.03E+01	×	NV	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	) ÷ (	47	×	25,550	)

**Notes:**

Derm - Risk – Dermal Risk  
 C<sub>sediment</sub> – Concentration in sediment  
 SF<sub>abs</sub> – Absorbed slope factor (SF<sub>0</sub> ÷ ABSd)  
 CF – Conversion factor  
 EF – Exposure Frequency  
 ET – Exposure Time  
 ED – Exposure Duration  
 EV – Event Frequency

SA – Skin Surface Area  
 SSAF – Sediment-to-skin Adherence Factor  
 ABSd – Dermal Sediment Absorption Factor  
 BW – Body Weight  
 ATc – Averaging Time for Carcinogens  
 NA – Not Applicable  
 NV – No toxicity value available for this pathway.

## Attachment D

**Table 20b**  
**Risk Calculations**  
**Adolescent Wader: Incidental Dermal Contact with Sediment Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csediment} \times \text{EF} \times \text{CF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ	=	(	Csediment	×	CF	×	EF	×	ED	×	EV	×	SA	×	SSAF	×	ABSd	)	÷	(	BW	×	ATn	×	RfDabs	)
	unitless			mg/kg		kg/mg		days/year		years		events/day		cm <sup>2</sup>		mg/cm <sup>2</sup> -event		unitless				kg		days		mg/kg-day	
Iron	NA	=	(	2.70E+04	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	)	÷	(	47	×	4,380	×	NV	)
Manganese	NA	=	(	3.00E+02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	)	÷	(	47	×	4,380	×	1.87E-03	)
Vanadium	NA	=	(	9.70E+00	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	)	÷	(	47	×	4,380	×	2.60E-05	)
1-Methylnaphthalene	NA	=	(	1.90E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
2-Methylnaphthalene	3.86E-02	=	(	5.46E+02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.00E-01	)	÷	(	47	×	4,380	×	4.00E-03	)
Acenaphthene	1.13E-03	=	(	1.85E+02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	6.00E-02	)
Benzo(a)anthracene	NA	=	(	3.96E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Benzo(a)pyrene	NA	=	(	2.86E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Benzo(b)fluoranthene	NA	=	(	1.50E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Benzo(g,h,i)perylene	NA	=	(	1.00E+00	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Benzo(k)fluoranthene	NA	=	(	1.91E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Chrysene	NA	=	(	3.53E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Dibenzo(a,h)anthracene	NA	=	(	1.90E+00	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Fluoranthene	7.96E-04	=	(	8.65E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	4.00E-02	)
Fluorene	1.04E-03	=	(	1.13E+02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	4.00E-02	)
Indeno(1,2,3-cd)pyrene	NA	=	(	5.30E+00	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	NV	)
Naphthalene	1.05E-02	=	(	5.73E+02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	2.00E-02	)
Pyrene	4.05E-05	=	(	1.10E+02	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	1.30E-01	)	÷	(	47	×	4,380	×	3.00E-02	)
Methylene chloride	NA	=	(	1.30E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	)	÷	(	47	×	4,380	×	6.00E-02	)
Xylenes (total)	NA	=	(	1.03E+01	×	1E-06	×	12	×	12	×	1	×	4,046	×	1	×	NA	)	÷	(	47	×	4,380	×	2.00E-01	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

Csediment – Concentration in sediment

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

SA – Skin Surface Area

SSAF – Sediment-to-skin Adherence Factor

ABSd – Dermal Sediment Absorption Factor

BW – Body Weight

ATn – Averaging Time for noncarcinogens

RfDabs – Absorbed reference dose (RfDo xABSgi)

NA – Not Applicable

NV – No toxicity value available for this pathway.

## Attachment D

**Table 21a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Csoil} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Ing - Risk unitless	= (	Csoil mg/kg	×	SFo kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATc days	)
<b>Inorganics</b>																				
Arsenic	3.12E-07	= (	4.51E+00	×	1.50E+00	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Lead	NA	= (	9.58E+01	×	a	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Manganese	NA	= (	3.08E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Vanadium	NA	= (	3.15E+01	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
<b>SVOCs</b>																				
1-Methylnaphthalene	NA	= (	1.44E+03	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
2-Methylnaphthalene	NA	= (	1.60E+03	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Acenaphthene	NA	= (	3.86E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Acenaphthylene	NA	= (	4.12E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Benzo(a)anthracene	5.74E-06	= (	1.71E+02	×	7.30E-01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Benzo(a)pyrene	4.13E-05	= (	1.23E+02	×	7.30E+00	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Benzo(b)fluoranthene	2.51E-06	= (	7.45E+01	×	7.30E-01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Benzo(k)fluoranthene	3.11E-07	= (	9.23E+01	×	7.30E-02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Chrysene	5.14E-08	= (	1.53E+02	×	7.30E-03	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Dibenzo(a,h)anthracene	6.18E-06	= (	1.83E+01	×	7.30E+00	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Dibenzofuran	NA	= (	9.89E+01	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Fluoranthene	NA	= (	2.82E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Fluorene	NA	= (	2.88E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Indeno(1,2,3-cd)pyrene	2.26E-06	= (	6.72E+01	×	7.30E-01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Naphthalene	NA	= (	1.17E+03	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Pyrene	NA	= (	3.95E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
<b>VOCs</b>																				
1,2,3-Trimethylbenzene	NA	= (	1.96E+01	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
1,2,4-Trichlorobenzene	NA	= (	2.64E+02	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
1,2,4-Trimethylbenzene	NA	= (	4.21E+00	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
1,3,5-Trimethylbenzene	NA	= (	1.97E+01	×	NV	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)
Benzene	3.83E-08	= (	1.51E+01	×	5.50E-02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	25,550	)

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## Attachment D

**Table 21a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Csoil} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Ing - Risk unitless	= (	Csoil mg/kg	$\times$	SFo kg-day/mg	$\times$	CF kg/mg	$\times$	EF days/year	$\times$	ED years	$\times$	SIR mg/day	$\times$	FI unitless	) $\div$ (	BW kg	$\times$	ATc days	)
Ethylbenzene	NA	= (	5.04E+01	$\times$	NV	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	330	$\times$	1	) $\div$ (	70	$\times$	25,550	)
n-Butyl benzene	NA	= (	5.93E+01	$\times$	NV	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	330	$\times$	1	) $\div$ (	70	$\times$	25,550	)
p-Isopropyltoluene	NA	= (	2.30E+01	$\times$	NV	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	330	$\times$	1	) $\div$ (	70	$\times$	25,550	)
sec-Butyl benzene	NA	= (	5.02E+01	$\times$	NV	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	330	$\times$	1	) $\div$ (	70	$\times$	25,550	)
Toluene	NA	= (	3.36E+01	$\times$	NV	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	330	$\times$	1	) $\div$ (	70	$\times$	25,550	)
Xylenes (total)	NA	= (	2.35E+02	$\times$	NV	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	330	$\times$	1	) $\div$ (	70	$\times$	25,550	)

**Notes:**

Ing - Risk – Ingestion risk

Csoil – Concentration in soil

SFo – Oral Slope Factor

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

VOC – Volatile organic compound

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SIR – Soil Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

SVOC – Semivolatile organic compound

## Attachment D

**Table 21b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo <sup>(b)</sup> mg/kg-day
<b>Inorganics</b>																			
Arsenic	4.9E-02	= (	4.51E+00	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	3.0E-04 )
Lead	NA	= (	9.58E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	a )
Manganese	7.1E-03	= (	3.08E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	1.4E-01 )
Vanadium	1.5E-02	= (	3.15E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	7.0E-03 )
<b>SVOCs</b>																			
1-Methylnaphthalene	6.6E-02	= (	1.44E+03	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	7.0E-02 )
2-Methylnaphthalene	1.3E+00	= (	1.60E+03	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	4.0E-03 )
Acenaphthene	2.1E-03	= (	3.86E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	6.0E-01 )
Acenaphthylene	NA	= (	4.12E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Benzo(a)anthracene	NA	= (	1.71E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Benzo(a)pyrene	NA	= (	1.23E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Benzo(b)fluoranthene	NA	= (	7.45E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Benzo(k)fluoranthene	NA	= (	9.23E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Chrysene	NA	= (	1.53E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Dibenz(a,h)anthracene	NA	= (	1.83E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Dibenzofuran	1.6E-01	= (	9.89E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	2.0E-03 )
Fluoranthene	2.3E-03	= (	2.82E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	4.0E-01 )
Fluorene	2.3E-03	= (	2.88E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	4.0E-01 )
Indeno(1,2,3-cd)pyrene	NA	= (	6.72E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
Naphthalene	1.9E-01	= (	1.17E+03	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	2.0E-02 )
Pyrene	4.3E-03	= (	3.95E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	3.0E-01 )
<b>VOCs</b>																			
1,2,3-Trimethylbenzene	NA	= (	1.96E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV )
1,2,4-Trichlorobenzene	8.5E-02	= (	2.64E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	1.0E-02 )
1,2,4-Trimethylbenzene	2.7E-04	= (	4.21E+00	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	5.0E-02 )
1,3,5-Trimethylbenzene	1.3E-04	= (	1.97E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	5.0E-01 )
Benzene	1.2E-02	= (	1.51E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	4.0E-03 )

## Attachment D

**Table 21b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo <sup>(b)</sup> mg/kg-day
Ethylbenzene	1.5E-03	= (	5.04E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	1.1E-01 )
n-Butyl benzene	4.8E-03	= (	5.93E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	4.0E-02 )
p-Isopropyltoluene	NA	= (	2.30E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	NV
sec-Butyl benzene	4.1E-03	= (	5.02E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	4.0E-02 )
Toluene	5.4E-05	= (	3.36E+01	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	2.0E+00 )
Xylenes (total)	2.1E-03	= (	2.35E+02	×	1E-06	×	250	×	1	×	330	×	1	) ÷ (	70	×	365	×	3.6E-01 )

**Notes:**

Ing - HQ – Ingestion Hazard

Csoil – Concentration in Soil

CF – Unit Conversion Factor

EF – Exposure Frequency

ED – Exposure Duration

SIR – Soil Ingestion Rate

VOC – Volatile organic compound

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

Toxicity criteria is presented in Attachment A, Table 1b.

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDo – Oral reference dose

NV – No toxicity value available for this pathway.

NA – Not Applicable

SVOC – Semivolatile organic compound

Attachment D

**Table 22a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csoil} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSD})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Derm - Risk unithless	= (	Csoil mg/kg	×	SFabs kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSD unitless	) ÷ (	BW kg	×	ATc days	)
<b>Inorganics</b>																								
Arsenic	1.73E-08	= (	4.51E+00	×	1.58E+00	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	3.00E-02	) ÷ (	70	×	25,550	)
Lead	NA	= (	9.58E+01	×	a	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
Manganese	NA	= (	3.08E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
Vanadium	NA	= (	3.15E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
<b>SVOCs</b>																								
1-Methylnaphthalene	NA	= (	1.44E+03	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
2-Methylnaphthalene	NA	= (	1.60E+03	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.00E-01	) ÷ (	70	×	25,550	)
Acenaphthene	NA	= (	3.86E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Acenaphthylene	NA	= (	4.12E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(a)anthracene	1.31E-06	= (	1.71E+02	×	7.30E-01	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(a)pyrene	9.41E-06	= (	1.23E+02	×	7.30E+00	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(b)fluoranthene	5.72E-07	= (	7.45E+01	×	7.30E-01	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Benzo(k)fluoranthene	7.09E-08	= (	9.23E+01	×	7.30E-02	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Chrysene	1.17E-08	= (	1.53E+02	×	7.30E-03	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Dibenz(a,h)anthracene	1.41E-06	= (	1.83E+01	×	7.30E+00	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Dibenzofuran	NA	= (	9.89E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Fluoranthene	NA	= (	2.82E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Fluorene	NA	= (	2.88E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Indeno(1,2,3-cd)pyrene	5.16E-07	= (	6.72E+01	×	7.30E-01	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Naphthalene	NA	= (	1.17E+03	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
Pyrene	NA	= (	3.95E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	1.30E-01	) ÷ (	70	×	25,550	)
<b>VOCs</b>																								
1,2,3-Trimethylbenzene	NA	= (	1.96E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
1,2,4-Trichlorobenzene	NA	= (	2.64E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NV	) ÷ (	70	×	25,550	)
1,2,4-Trimethylbenzene	NA	= (	4.21E+00	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
1,3,5-Trimethylbenzene	NA	= (	1.97E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)

## Attachment D

**Table 22a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(\text{Csoil} \times \text{SFabs} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Derm - Risk unitless	= (	Csoil mg/kg	×	SFabs kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSd unitless	) ÷ (	BW kg	×	ATc days	)
Benzene	NA	= (	1.51E+01	×	5.50E-02	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
Ethylbenzene	NA	= (	5.04E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
n-Butyl benzene	NA	= (	5.93E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
p-Isopropyltoluene	NA	= (	2.30E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NV	) ÷ (	70	×	25,550	)
sec-Butyl benzene	NA	= (	5.02E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
Toluene	NA	= (	3.36E+01	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)
Xylenes (total)	NA	= (	2.35E+02	×	NV	×	1E-06	×	250	×	1	×	1	×	1,930	×	0.3	×	NA	) ÷ (	70	×	25,550	)

**Notes:**

Derm - Risk – Dermal Risk

Csoil – Concentration in Soil

SFabs – Absorbed slope factor (SFo ÷ ABSgi)

CF – Conversion factor

EF – Exposure Frequency

ED – Exposure Duration

EV – Event Frequency

VOC – Volatile organic compound

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

**Attachment D**

**Table 22b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ	=	(	Csoil	$\times$	CF	$\times$	EF	$\times$	ED	$\times$	EV	$\times$	SA	$\times$	SSAF	$\times$	ABSd	) $\div$ (	BW	$\times$	ATn	$\times$	RfDabs <sup>(1)</sup>	
	unitless			mg/kg		kg/mg		days/year		years		events/day		cm <sup>2</sup>		mg/cm <sup>2</sup> -event		unitless		kg		days		mg/kg-day	
<b>Inorganics</b>																									
Arsenic	2.69E-03	=	(	4.51E+00	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	3.00E-02	) $\div$ (	70	$\times$	365	$\times$	2.85E-04	)
Lead	NA	=	(	9.58E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	a	)
Manganese	NA	=	(	3.08E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	5.60E-03	
Vanadium	NA	=	(	3.15E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	1.82E-04	
<b>SVOCs</b>																									
1-Methylnaphthalene	1.51E-02	=	(	1.44E+03	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	7.00E-02	)
2-Methylnaphthalene	2.26E-01	=	(	1.60E+03	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.00E-01	) $\div$ (	70	$\times$	365	$\times$	4.00E-03	)
Acenaphthene	4.74E-04	=	(	3.86E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	6.00E-01	)
Acenaphthylene	NA	=	(	4.12E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	
Benz(a)anthracene	NA	=	(	1.71E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Benz(a)pyrene	NA	=	(	1.23E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Benz(b)fluoranthene	NA	=	(	7.45E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Benz(k)fluoranthene	NA	=	(	9.23E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Chrysene	NA	=	(	1.53E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Dibenzo(a,h)anthracene	NA	=	(	1.83E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Dibenzofuran	3.64E-02	=	(	9.89E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	2.00E-03	)
Fluoranthene	5.20E-04	=	(	2.82E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	4.00E-01	)
Fluorene	5.29E-04	=	(	2.88E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	4.00E-01	)
Indeno(1,2,3-cd)pyrene	NA	=	(	6.72E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	NV	)
Naphthalene	4.30E-02	=	(	1.17E+03	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	2.00E-02	)
Pyrene	9.71E-04	=	(	3.95E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	1.30E-01	) $\div$ (	70	$\times$	365	$\times$	3.00E-01	)
<b>VOCs</b>																									
1,2,3-Trimethylbenzene	NA	=	(	1.96E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	NV	
1,2,4-Trichlorobenzene	NA	=	(	2.64E+02	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NV	) $\div$ (	70	$\times$	365	$\times$	NV	)
1,2,4-Trimethylbenzene	NA	=	(	4.21E+00	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	5.00E-02	)
1,3,5-Trimethylbenzene	NA	=	(	1.97E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	5.00E-01	)
Benzene	NA	=	(	1.51E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	4.00E-03	)
Ethylbenzene	NA	=	(	5.04E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	1.10E-01	)
n-Butyl benzene	NA	=	(	5.93E+01	$\times$	1E-06	$\times$	250	$\times$	1	$\times$	1	$\times$	1,930	$\times$	0.3	$\times$	NA	) $\div$ (	70	$\times$	365	$\times$	4.00E-02	)

## Attachment D

**Table 22b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ unitless	Csoil mg/kg	CF kg/mg	EF days/year	ED years	EV events/day	SA cm <sup>2</sup>	SSAF mg/cm <sup>2</sup> -event	ABSd unitless	) ÷ (	BW kg	ATn days	RfDabs <sup>(a)</sup> mg/kg-day
p-Isopropyltoluene	NA	= ( 2.30E+01 × 1E-06 × 250 × 1 × 1 × 1,930 × 0.3 × NV ) ÷ ( 70 × 365 × NV											
sec-Butyl benzene	NA	= ( 5.02E+01 × 1E-06 × 250 × 1 × 1 × 1,930 × 0.3 × NA ) ÷ ( 70 × 365 × 4.00E-02 )											
Toluene	NA	= ( 3.36E+01 × 1E-06 × 250 × 1 × 1 × 1,930 × 0.3 × NA ) ÷ ( 70 × 365 × 2.00E+00 )											
Xylenes (total)	NA	= ( 2.35E+02 × 1E-06 × 250 × 1 × 1 × 1,930 × 0.3 × NA ) ÷ ( 70 × 365 × 3.57E-01 )											

**Notes:**

Derm - HQ – Dermal Hazard Quotient

ABSd – Dermal Soil Absorption Factor

Csoil – Concentration in Soil

BW – Body Weight

CF – Unit Conversion Factor

ATn – Averaging Time for noncarcinogens

EF – Exposure Frequency

RfDabs – Absorbed reference dose (RfDo × ABSgi)

ED – Exposure Duration

NA – Not Applicable

EV – Event Frequency

NV – No toxicity value available for this pathway.

SA – Skin Surface Area

VOC – Volatile organic compound

SSAF – Soil-to-skin Adherence Factor

SVOC – Semivolatile organic compound

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

Toxicity criteria is presented in Attachment A, Table 1b.

Attachment D

**Table 23a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Inhalation of Soil (Fugitive Emissions and Volatile Compounds) Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFi} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unitless	= ( Csoil mg/kg	× SFi kg-day/mg	× IR m³/hour	× ET hours/day	× EF days/year	× ED year	× [ 1 / VF m³/kg	+ 1 / PEF m³/kg	] ÷ ( BW kg	× ATc days
<b>Inorganics</b>											
Arsenic	8.32E-09	= ( 4.51E+00 × 1.51E+01 × 1.5 × 8 × 250 × 1 × [ 1 / NA	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Lead	NA	= ( 9.58E+01 × a × 1.5 × 8 × 250 × 1 × [ 1 / NA	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Manganese	NA	= ( 3.08E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NA	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Vanadium	NA	= ( 3.15E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NA	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
<b>SVOCs</b>											
1-Methylnaphthalene	NA	= ( 1.44E+03 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 6.00E+03	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
2-Methylnaphthalene	NA	= ( 1.60E+03 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 5.68E+03	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Acenaphthene	NA	= ( 3.86E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 1.10E+04	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Acenaphthylene	NA	= ( 4.12E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 1.30E+04	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Benzo(a)anthracene	NA	= ( 1.71E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Benzo(a)pyrene	4.62E-08	= ( 1.23E+02 × 3.08E+00 × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Benzo(b)fluoranthene	NA	= ( 7.45E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Benzo(k)fluoranthene	NA	= ( 9.23E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Chrysene	NA	= ( 1.53E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Dibenz(a,h)anthracene	NA	= ( 1.83E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Dibenzofuran	NA	= ( 9.89E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 9.09E+03	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Fluoranthene	NA	= ( 2.82E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Fluorene	NA	= ( 2.88E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 1.67E+04	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Indeno(1,2,3-cd)pyrene	NA	= ( 6.72E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NC	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Naphthalene	NA	= ( 1.17E+03 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 5.25E+03	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Pyrene	NA	= ( 3.95E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 5.57E+04	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
<b>VOCs</b>											
1,2,3-Trimethylbenzene	NA	= ( 1.96E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 1.35E+03	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
1,2,4-Trichlorobenzene	NA	= ( 2.64E+02 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 2.62E+04	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
1,2,4-Trimethylbenzene	NA	= ( 4.21E+00 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 9.98E+02	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
1,3,5-Trimethylbenzene	NA	= ( 1.97E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 8.26E+02	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Benzene	1.19E-06	= ( 1.51E+01 × 2.73E-02 × 1.5 × 8 × 250 × 1 × [ 1 / 5.83E+02	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
Ethylbenzene	NA	= ( 5.04E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 7.41E+02	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
n-Butyl benzene	NA	= ( 5.93E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 7.70E+02	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
p-Isopropyltoluene	NA	= ( 2.30E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / NV	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								
sec-Butyl benzene	NA	= ( 5.02E+01 × NV × 1.5 × 8 × 250 × 1 × [ 1 / 7.70E+02	+ 1 / 1.37E+07 ] ) ÷ ( 70 × 25,550 )								

**Attachment D**

**Table 23a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Construction Worker: Incidental Inhalation of Soil (Fugitive Emissions and Volatile Compounds) Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFi} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unitless	= (	Csoil mg/kg	×	SFi kg-day/mg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / VF m³/kg ]	+ 1 / PEF m³/kg ]	1 ) ÷ (	BW kg	×	ATc days
Toluene	NA	= (	3.36E+01	×	NV	×	1.5	×	8	×	250	×	1	×	[ 1 / 6.32E+02 ]	+ 1 / 1.37E+07 ]	) ÷ (	70	×	25,550 )
Xylenes (total)	NA	= (	2.35E+02	×	NV	×	1.5	×	8	×	250	×	1	×	[ 1 / 8.09E+02 ]	+ 1 / 1.37E+07 ]	) ÷ (	70	×	25,550 )

**Notes:**

Inh - Risk – Inhalation Risk  
 Csoil – Concentration in Soil  
 SFi – Inhalation Slope Factor  
 IR – Inhalation Rate  
 ET – Exposure Time  
 EF – Exposure frequency  
 ED – Exposure duration  
 VOC – Volatile organic compound

VF – Volatilization Factor  
 PEF – Particulate Emission Factor (See Attachment G)  
 BW – Body Weight  
 ATc – Averaging Time for Carcinogens  
 NV – No toxicity value available for this pathway.  
 NA – Not Applicable  
 NC – Not Calculated  
 SVOC – Semivolatile organic compound

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.  
 Toxicity criteria for lead have not been derived by USEPA.

## Attachment D

**Table 23b**

**Risk Calculations: Reasonable Maximum Exposure**

**Construction Worker: Incidental Inhalation of Soil (Fugitive Emissions and Volatile Compounds) Pathway – Carcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Csoil} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times ([1/\text{VF}] + [1/\text{PEF}]))}{(\text{BW} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= ( Csoil mg/kg	$\times$	IR m³/hour	$\times$	ET hours/day	$\times$	EF days/year	$\times$	ED year	$\times$	[ 1 / VF m³/kg	+ 1 / PEF m³/kg	]	$\div$ ( BW kg	$\times$	ATn days	$\times$	RfDi (b) mg/kg-day
<b>Inorganics</b>																			
Arsenic	NA	= ( 4.51E+00	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NA	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Lead	NA	= ( 9.58E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NA	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	a )
Manganese	1.85E-01	= ( 3.08E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NA	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	1.43E-05
Vanadium	NA	= ( 3.15E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NA	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
<b>SVOCs</b>																			
1-Methylnaphthalene	NA	= ( 1.44E+03	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 6.00E+03	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
2-Methylnaphthalene	NA	= ( 1.60E+03	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 5.68E+03	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Acenaphthene	NA	= ( 3.86E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 1.10E+04	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Acenaphthylene	NA	= ( 4.12E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 1.30E+04	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Benz(a)anthracene	NA	= ( 1.71E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Benz(a)pyrene	NA	= ( 1.23E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Benz(b)fluoranthene	NA	= ( 7.45E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Benz(k)fluoranthene	NA	= ( 9.23E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Chrysene	NA	= ( 1.53E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Dibenzo(a,h)anthracene	NA	= ( 1.83E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Dibenzofuran	NA	= ( 9.89E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 9.09E+03	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Fluoranthene	NA	= ( 2.82E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Fluorene	NA	= ( 2.88E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 1.67E+04	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Indeno(1,2,3-cd)pyrene	NA	= ( 6.72E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / NC	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
Naphthalene	3.05E+01	= ( 1.17E+03	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 5.25E+03	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	8.57E-04 )
Pyrene	NA	= ( 3.95E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 5.57E+04	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
<b>VOCs</b>																			
1,2,3-Trimethylbenzene	NA	= ( 1.96E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 1.35E+03	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )
1,2,4-Trichlorobenzene	1.04E+00	= ( 2.64E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 2.62E+04	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	1.14E-03 )
1,2,4-Trimethylbenzene	2.90E-01	= ( 4.21E+00	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 9.98E+02	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	1.71E-03 )
1,3,5-Trimethylbenzene	1.65E-01	= ( 1.97E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 8.26E+02	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	1.70E-02 )
Benzene	3.55E-01	= ( 1.51E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 5.83E+02	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	8.57E-03 )
Ethylbenzene	2.76E-02	= ( 5.04E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 7.41E+02	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	2.90E-01
n-Butyl benzene	NA	= ( 5.93E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[ 1 / 7.70E+02	+ 1 / 1.37E+07	]	$\div$ ( 70	$\times$	365	$\times$	NV )

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## Attachment D

**Table 23b**

**Risk Calculations: Reasonable Maximum Exposure**

**Construction Worker: Incidental Inhalation of Soil (Fugitive Emissions and Volatile Compounds) Pathway – Carcinogenic Effects**

$$\text{Inh - HQ} = \frac{(C_{\text{soil}} \times IR \times ET \times EF \times ED \times ([1/VF] + [1/PEF]))}{(BW \times ATn \times RfDi)}$$

Equation Units	Inh - HQ unitless	$= ($	$C_{\text{soil}}$	$\times$	IR	$\times$	ET	$\times$	EF	$\times$	ED	$\times$	[	1 /	VF	$+ 1 /$	PEF	]	$\div ($	BW	$\times$	ATn	$\times$	RfDi <sup>(b)</sup>	)
			mg/kg										m³/kg		m³/kg		kg		days		mg/kg-day				
p-Isopropyltoluene	NA	$= ($	2.30E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[	1 /	NV	$+ 1 /$	1.37E+07	$]$	$\div ($	70	$\times$	365	$\times$	NV	
sec-Butyl benzene	NA	$= ($	5.02E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[	1 /	7.70E+02	$+ 1 /$	1.37E+07	$]$	$\div ($	70	$\times$	365	$\times$	NV	
Toluene	2.40E-02	$= ($	3.36E+01	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[	1 /	6.32E+02	$+ 1 /$	1.37E+07	$]$	$\div ($	70	$\times$	365	$\times$	2.60E-01	
Xylenes (total)	1.19E+00	$= ($	2.35E+02	$\times$	1.5	$\times$	8	$\times$	250	$\times$	1	$\times$	[	1 /	8.09E+02	$+ 1 /$	1.37E+07	$]$	$\div ($	70	$\times$	365	$\times$	2.86E-02	

**Notes:**

Inh - Risk – Inhalation Hazard Quotient

Csoil – Concentration in Soil

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

VF – Volatilization Factor

VOC – Volatile organic compound

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

b – Subchronic toxicity values were used for each individual chemical, chronic toxicity values were used if subchronic values were not available.

Toxicity criteria is presented in Attachment A, Table 1b.

PEF – Particulate Emission Factor (See Attachment G)

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDi – Inhalation Reference Dose

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

SVOC – Semivolatile organic compound

## Attachment D

**Table 23c**  
**Construction Worker: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^2}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>3</sup> ·s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>2</sup> /cm <sup>2</sup> )	VF (m <sup>3</sup> /kg)
1-Methylnaphthalene	73.32	3.14	1.94E-05	3.15E+07	2	1.38	1.00E-04	6.00E+03
2-Methylnaphthalene	73.32	3.14	2.17E-05	3.15E+07	2	1.38	1.00E-04	5.68E+03
Acenaphthene	73.32	3.14	5.82E-06	3.15E+07	2	1.38	1.00E-04	1.10E+04
Benzo(a)anthracene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Benzo(a)pyrene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Benzo(b)fluoranthene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Benzo(k)fluoranthene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Chrysene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Dibenzo(a,h)anthracene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Dibenzofuran	73.32	3.14	8.46E-06	3.15E+07	2	1.38	1.00E-04	9.09E+03
Fluoranthene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Fluorene	73.32	3.14	2.50E-06	3.15E+07	2	1.38	1.00E-04	1.67E+04
Indeno(1,2,3-cd)pyrene	73.32	3.14	NC	3.15E+07	2	1.38	1.00E-04	NC
Naphthalene	73.32	3.14	2.54E-05	3.15E+07	2	1.38	1.00E-04	5.25E+03
Pyrene	73.32	3.14	2.25E-07	3.15E+07	2	1.38	1.00E-04	5.57E+04
1,2,4-Trichlorobenzene	73.32	3.14	1.02E-06	3.15E+07	2	1.38	1.00E-04	2.62E+04
1,2,4-Trimethylbenzene	73.32	3.14	7.01E-04	3.15E+07	2	1.38	1.00E-04	9.98E+02
1,3,5-Trimethylbenzene	73.32	3.14	1.02E-03	3.15E+07	2	1.38	1.00E-04	8.26E+02
Benzene	73.32	3.14	2.05E-03	3.15E+07	2	1.38	1.00E-04	5.83E+02
Ethylbenzene	73.32	3.14	1.27E-03	3.15E+07	2	1.38	1.00E-04	7.41E+02
sec-Butyl benzene	73.32	3.14	1.18E-03	3.15E+07	2	1.38	1.00E-04	7.70E+02
Toluene	73.32	3.14	1.75E-03	3.15E+07	2	1.38	1.00E-04	6.32E+02
Xylenes (total)	73.32	3.14	1.07E-03	3.15E+07	2	1.38	1.00E-04	8.09E+02

Notes:

Default values are as presented in Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002).

VF – Volatilization Factor (m<sup>3</sup>/kg) (calculated)

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source (g/m<sup>3</sup>·s)/(kg/m<sup>3</sup>) (Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T – Exposure interval (s)

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated

**Attachment D**

**Table 23d**  
**Construction Worker: Apparent Diffusivity Calculations**

Equation:

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H')}$$

Chemical Units	VOC?	$\theta_a$ (Lair / Lsoil )	$D_i$ (cm <sup>2</sup> /s)	$H'$ unitless	$\theta_w$ (Lwater / Lsoil )	$D_w$ (cm <sup>2</sup> /s)	$\eta$ (Lpore / Lsoil )	$\rho_b$ (g/cm <sup>3</sup> )	$\rho_s$ (g/cm <sup>3</sup> )	$K_d$ (cm <sup>3</sup> /g)	$D_A$ (cm <sup>2</sup> /s)
1-Methylnaphthalene	Yes	3.29E-01	6.31E-02	1.64E-02	0.15	7.13E-06	4.79E-01	1.38	2.65	3.75E+01	1.948E-05
2-Methylnaphthalene	Yes	3.29E-01	4.80E-02	2.12E-02	0.15	7.84E-06	4.79E-01	1.38	2.65	1.79E+01	2.166E-05
Acenaphthene	Yes	3.29E-01	4.21E-02	7.44E-03	0.15	7.69E-06	4.79E-01	1.38	2.65	3.67E+01	5.819E-06
Benzo(a)anthracene	No	3.29E-01	5.10E-02	4.91E-04	0.15	9.00E-06	4.79E-01	1.38	2.65	1.39E+03	NC
Benzo(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Benzo(b)fluoranthene	No	3.29E-01	2.26E-02	2.69E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.82E+03	NC
Benzo(k)fluoranthene	No	3.29E-01	2.26E-02	2.39E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Chrysene	No	3.29E-01	2.48E-02	2.14E-04	0.15	6.21E-06	4.79E-01	1.38	2.65	1.42E+03	NC
Dibenzo(a,h)anthracene	No	3.29E-01	2.02E-02	5.03E-06	0.15	5.18E-06	4.79E-01	1.38	2.65	1.57E+04	NC
Dibenzofuran	Yes	3.29E-01	5.51E-02	8.71E-03	0.15	7.04E-06	4.79E-01	1.38	2.65	6.78E+01	8.463E-06
Fluoranthene	No	3.29E-01	3.02E-02	3.62E-04	0.15	6.35E-06	4.79E-01	1.38	2.65	4.25E+02	NC
Fluorene	Yes	3.29E-01	3.63E-02	3.93E-03	0.15	7.88E-06	4.79E-01	1.38	2.65	6.78E+01	2.499E-06
Indeno(1,2,3-cd)pyrene	No	3.29E-01	1.90E-02	1.42E-05	0.15	5.66E-06	4.79E-01	1.38	2.65	1.61E+04	NC
Naphthalene	Yes	3.29E-01	5.90E-02	1.80E-02	0.15	7.50E-06	4.79E-01	1.38	2.65	1.10E+01	2.537E-05
Pyrene	Yes	3.29E-01	2.72E-02	4.87E-04	0.15	7.24E-06	4.79E-01	1.38	2.65	4.16E+02	2.254E-07
1,2,4-Trichlorobenzene	NV	3.29E-01	3.00E-02	1.42E-03	0.15	8.23E-06	4.79E-01	1.38	2.65	1.07E-01	1.02E-06
1,2,4-Trimethylbenzene	Yes	3.29E-01	6.44E-02	2.52E-01	0.15	7.92E-06	4.79E-01	1.38	2.65	4.31E+00	7.01E-04
1,3,5-Trimethylbenzene	Yes	3.29E-01	6.02E-02	3.59E-01	0.15	8.67E-06	4.79E-01	1.38	2.65	4.22E+00	1.02E-03
Benzene	Yes	3.29E-01	8.80E-02	2.27E-01	0.15	9.80E-06	4.79E-01	1.38	2.65	9.93E-01	2.05E-03
Ethylbenzene	Yes	3.29E-01	7.50E-02	3.22E-01	0.15	7.80E-06	4.79E-01	1.38	2.65	3.11E+00	1.27E-03
sec-Butyl benzene	Yes	3.29E-01	5.76E-02	5.07E-01	0.15	6.75E-06	4.79E-01	1.38	2.65	1.25E+01	1.18E-03
Toluene	Yes	3.29E-01	8.70E-02	2.71E-01	0.15	8.60E-06	4.79E-01	1.38	2.65	1.61E+00	1.75E-03
Xylenes (total)	Yes	3.29E-01	7.14E-02	2.71E-01	0.15	9.34E-06	4.79E-01	1.38	2.65	2.66E+00	1.07E-03

Notes:

$D_A$  – apparent diffusivity  
 $\theta_a$  – air-filled soil porosity  
 $D_i$  – diffusivity in air  
 $H'$  – dimensionless Henry's Law constant  
 $\theta_w$  – water-filled soil porosity  
 $D_w$  – diffusivity in water  
 $\eta$  – total soil porosity  
 $\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User'S Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).  
 $\rho_s$  – soil particle density  
 $K_d$  – soil-water partition coefficient, where:  
 $K_d = K_{oc} \times f_{oc}$   
 $K_{oc}$  – soil organic carbon partition coefficient (cm<sup>3</sup>/g)  
 $f_{oc}$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)  
VOC? – Volatile organic compounds; If no an apparent diffusivity was not calculated.  
NV – no value available  
NC – not calculated

Attachment D

**Table 23e**  
**Calculation of Blood Lead Concentrations (PbBs) for Non-residential Receptors (Construction Workers)**

Exposure Variable	PbB Equation <sup>1</sup>		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
	1*	2**			Using Equation 1		Using Equation 2	
	GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het			GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het	GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het
PbS	X	X	Soil lead concentration (site-specific average concentration)	ug/g or ppm	88.74	88.74	88.74	88.74
R <sub>fetal/maternal</sub>	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD <sub>i</sub>	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3
PbB <sub>0</sub>	X	X	Baseline PbB	ug/dL	1.5	1.7	1.5	1.7
IR <sub>S</sub>	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR <sub>S+D</sub>		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W <sub>S</sub>		X	Weighting factor; fraction of IR <sub>S+D</sub> ingested as outdoor soil	--	--	--	1.0	1.0
K <sub>SD</sub>		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
AF <sub>S, D</sub>	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
EF <sub>S, D</sub>	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
AT <sub>S, D</sub>	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB <sub>adult</sub>	PbB of adult worker, geometric mean			ug/dL	1.6	1.8	1.6	1.8
PbB <sub>fetal, 0.95</sub>	95th percentile PbB among fetuses of adult workers			ug/dL	5.0	6.5	5.0	6.5
PbB <sub>t</sub>	Target PbB level of concern (e.g., 10 ug/dL)			ug/dL	10.0	10.0	10.0	10.0
P(PbB <sub>fetal</sub> > PbB <sub>t</sub> )	Probability that fetal PbB > PbB <sub>t</sub> , assuming lognormal distribution			%	0.5%	1.5%	0.5%	1.5%

<sup>1</sup> Equation 1 does not apportion exposure between soil and dust ingestion (excludes W<sub>S</sub>, K<sub>SD</sub>).

When IR<sub>S</sub> = IR<sub>S+D</sub> and W<sub>S</sub> = 1.0, the equations yield the same PbB<sub>fetal,0.95</sub>.

\*Equation 1, based on Eq. 1, 2 in USEPA (1996).

<b>PbB<sub>adult</sub> =</b>	$(PbS * BKSF * IR_{S+D} * AF_{S,D} * EF_S / AT_{S,D}) + PbB_0$
<b>PbB<sub>fetal, 0.95</sub> =</b>	$PbB_{adult} * (GSD_i^{1.645} * R)$

\*\*Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).

<b>PbB<sub>adult</sub> =</b>	$PbS * BKSF * [(IR_{S+D}) * AF_S * EF_S * W_S] + [K_{SD} * (IR_{S+D}) * (1 - W_S) * AF_D * EF_D] / 365 + PbB_0$
<b>PbB<sub>fetal, 0.95</sub> =</b>	$PbB_{adult} * (GSD_i^{1.645} * R)$

## Attachment D

**Table 24a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Csoil} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Ing - Risk unitless	= (	Csoil mg/kg	×	SFo kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATc days
<b>Inorganics</b>																			
Arsenic	9.58E-07	= (	3.65E+00	×	1.50E+00	×	1E-06	×	250	×	25	×	50	×	1	) ÷ (	70	×	25,550
<b>SVOCs</b>																			
Benzo(a)pyrene	2.31E-07	= (	1.81E-01	×	7.30E+00	×	1E-06	×	250	×	25	×	50	×	1	) ÷ (	70	×	25,550

**Notes:**

ATc – Averaging Time for Carcinogens

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

Ing - Risk – Ingestion risk

CF – Unit Conversion Factor

SFo – Oral Slope Factor

Csoil – Soil Concentration

SIR – Soil Ingestion Rate

ED – Exposure Duration

SVOC – Semivolatile organic compound

EF – Exposure Frequency

## Attachment D

**Table 24b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

Ing - HQ = $\frac{(C_{soil} \times CF \times EF \times ED \times SIR \times FI)}{(BW \times ATn \times RfDo)}$																			
Equation Units	Ing - HQ unitless	= (	C <sub>soil</sub> mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day
<b>Inorganics</b>																			
Arsenic	6.0E-03	= (	3.65E+00	×	1E-06	×	250	×	25	×	50	×	1	) ÷ (	70	×	9,125	×	3.0E-04
<b>SVOCs</b>																			
Benzo(a)pyrene	NA	= (	1.81E-01	×	1E-06	×	250	×	25	×	50	×	1	) ÷ (	70	×	9,125	×	NV

**Notes:**

ATn – Averaging Time for Noncarcinogens

Ing - HQ – Ingestion Hazard

BW – Body Weight

NA – Not Applicable

CF – Unit Conversion Factor

NV – No toxicity value available for this pathway.

C<sub>soil</sub> – Soil Concentration

RfDo – Oral reference dose

ED – Exposure Duration

SIR – Soil Ingestion Rate

EF – Exposure Frequency

SVOC – Semivolatile organic compound

FI – Fraction Ingested from Contaminated Source

## Attachment D

**Table 25a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(C_{\text{soil}} \times SF_{\text{abs}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATc)}$$

Equation Units	Derm - Risk unitless	= (	C <sub>soil</sub> mg/kg	×	SF <sub>abs</sub> kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSd unitless	) ÷ (	BW kg	×	ATc days	)	
<b>Inorganics</b>																									
Arsenic	2.00E-07	= (	3.65E+00	×	1.58E+00	×	1E-06	×	250	×	25	×	1	×	3,300	×	0.1	×	3.00E-02	) ÷ (	70	×	25,550	)	
SVOCs	Benzo(a)pyrene	NA	= (	1.81E-01	×	NV	×	1E-06	×	250	×	25	×	1	×	3,300	×	0.1	×	1.30E-01	) ÷ (	70	×	25,550	)

**Notes:**

ABSD – Dermal Soil Absorption Factor

EF – Exposure Frequency

ATC – Averaging Time for Carcinogens

EV – Event Frequency

BW – Body Weight

SA – Skin Surface Area

CF – Conversion factor

SFabs – Absorbed slope factor (SFo ÷ ABSgi)

Csoil – Soil Concentration

SSAF – Soil-to-skin Adherence Factor

Derm - Risk – Dermal Risk

SVOC – Semivolatile organic compound

ED – Exposure Duration

## Attachment D

**Table 25b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(C_{\text{soil}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATn \times RfDabs)}$$

Equation Units	Derm - HQ	=	(	C <sub>soil</sub> mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	EV events/day	×	SA cm <sup>2</sup>	×	SSAF mg/cm <sup>2</sup> -event	×	ABSd unitless	)	÷	(	BW kg	×	ATn days	×	RfDabs mg/kg-day	)	
<b>Inorganics</b>																												
Arsenic	1.24E-03	=	(	3.65E+00	×	1E-06	×	250	×	25	×	1	×	3,300	×	0.1	×	3.00E-02	)	÷	(	70	×	9,125	×	2.85E-04	)	
SVOCs	Benzo(a)pyrene	NA	=	(	1.81E-01	×	1E-06	×	250	×	25	×	1	×	3,300	×	0.1	×	1.30E-01	)	÷	(	70	×	9,125	×	NV	)

**Notes:**

ABSD – Dermal Soil Absorption Factor

EV – Event Frequency

ATn – Averaging Time for noncarcinogens

NA – Not Applicable

BW – Body Weight

NV – No toxicity value available for this pathway.

CF – Conversion factor

RfDabs – Absorbed reference dose (RfDo × ABSgi)

Csoil – Soil Concentration

SA – Skin Surface Area

Derm - HQ – Dermal Hazard Quotient

SSAF – Soil-to-skin Adherence Factor

ED – Exposure Duration

SVOC – Semivolatile organic compound

EF – Exposure Frequency

## Attachment D

**Table 26a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Inhalation of Soil-derived Chemicals Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFi} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unitless	= (	Csoil mg/kg	×	SFi kg-day/mg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	× [ 1 /	VF m³/kg	+ 1 /	PEF m³/kg	] ) ÷ (	BW kg	×	ATc days		
<b>Inorganics</b>																							
Arsenic	3.03E-10	= (	3.65E+00	×	1.51E+01	×	1	×	8	×	250	×	25	×	[ 1 /	NA	+ 1 /	5.07E+09	] ) ÷ (	70	×	25,550 )	
SVOCs	Benzo(a)pyrene	3.07E-12	= (	1.81E-01	×	3.08E+00	×	1	×	8	×	250	×	25	×	[ 1 /	NC	+ 1 /	5.07E+09	] ) ÷ (	70	×	25,550 )

**Notes:**

ATc – Averaging Time for Carcinogens

BW – Body Weight

Csoil – Soil Concentration

ED – Exposure duration

EF – Exposure frequency

ET – Exposure Time

Inh - Risk – Inhalation Risk

IR – Inhalation Rate

NA – Not Applicable

NC – Not Calculated

PEF – Particulate Emission Factor

SFi – Inhalation Slope Factor

SVOC – Semivolatile organic compound

VF – Volatilization Factor

## Attachment D

**Table 26b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Inhalation of Soil-derived Chemicals Pathway – Noncarcinogenic Effects**

$$\text{Inh - HQ} = \frac{(C_{\text{soil}} \times IR \times ET \times EF \times ED \times ([1/VF] + [1/PEF]))}{(BW \times ATn \times RfDi)}$$

Equation Units	Inh - HQ	=	(	C <sub>soil</sub>	×	IR	×	ET	×	EF	×	ED	×	[ 1 / year ]	VF	+ 1 /	PEF	)	÷	(	BW	×	ATn	×	RfDi
	unitless			mg/kg		m <sup>3</sup> /hour		hours/day		days/year		year		m <sup>3</sup> /kg		m <sup>3</sup> /kg		kg		days		mg/kg-day			
<b>Inorganics</b>																									
Arsenic	NA	=	(	3.65E+00	×	1	×	8	×	250	×	25	×	[ 1 / year ]	NA	+ 1 /	5.07E+09	)	÷	(	70	×	9,125	×	NV
<b>SVOCs</b>																									
Benzo(a)pyrene	NA	=	(	1.81E-01	×	1	×	8	×	250	×	25	×	[ 1 / year ]	NC	+ 1 /	5.07E+09	)	÷	(	70	×	9,125	×	NV

**Notes:**

ATn – Averaging Time for Noncarcinogens

NA – Not Applicable

BW – Body Weight

NC – Not Calculated

C<sub>soil</sub> – Soil Concentration

NV – No toxicity value available for this pathway.

ED – Exposure duration

PEF – Particulate Emission Factor

EF – Exposure frequency

RfDi – Inhalation Reference Dose

ET – Exposure Time

SVOC – Semivolatile organic compound

Inh - Risk – Inhalation Hazard Quotient

VF – Volatilization Factor

IR – Inhalation Rate

## Attachment D

**Table 26c**  
**Industrial Worker: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^3}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>2</sup> /cm <sup>3</sup> )	VF (m <sup>2</sup> /kg)
Benzo(a)pyrene	73.32	3.14	NC	7.88E+08	2	1.38	1.00E-04	NC

Notes:

Default values are as presented in Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002).

VF – Volatilization Factor (m<sup>2</sup>/kg) (calculated)

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source  
(g/m<sup>2</sup>-s)/(kg/m<sup>3</sup>)(Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T – Exposure interval (s)

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated; PAHs are not considered volatile chemicals

## Attachment D

**Table 26d**  
**Industrial Worker: Apparent Diffusivity Calculations**

Equation:

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H)}$$

Chemical Units	VOC?	$\theta_a$ (Lair /Lsoil )	$D_i$ (cm <sup>2</sup> /s)	$H'$ unitless	$\theta_w$ (Lwater /Lsoil )	$D_w$ (cm <sup>2</sup> /s)	$\eta$ (Lpore /Lsoil )	$\rho_b$ (g/cm <sup>3</sup> )	$\rho_s$ (g/cm <sup>3</sup> )	$K_d$ (cm <sup>3</sup> /g)	$D_A$ (cm <sup>2</sup> /s)
Benzo(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC

Notes:

$D_A$  – apparent diffusivity

$\theta_a$  – air-filled soil porosity

$D_i$  – diffusivity in air

$H'$  – dimensionless Henry's Law constant

$\theta_w$  – water-filled soil porosity

$D_w$  – diffusivity in water

$\eta$  – total soil porosity

$\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User's Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).

$\rho_s$  – soil particle density

$K_d$  – soil-water partition coefficient, where:

$$K_d = K_{oc} \times f_{oc}$$

$K_{oc}$  – soil organic carbon partition coefficient (cm<sup>3</sup>/g)

$f_{oc}$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)

VOC? – Volatile organic compounds; If no, an apparent diffusivity was not calculated.

NV – No value available

NC – not calculated

**Attachment D**

**Table 27a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Inhalation of Chemicals in Indoor Air Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Cair} \times \text{SFi} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unitless	Cair mg/m³	SFi kg-day/mg	IR m³/hour	ET hours/day	EF days/year	ED year	BW kg	ATc days
1,2,4-Trimethylbenzene	NA	= ( 3.88E-02	× NV	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )
1,3,5-Trimethylbenzene	NA	= ( 9.32E-03	× NV	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )
1,4-Dichlorobenzene	NA	= ( 9.62E-01	× NV	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )
Benzene	2.92E-05	= ( 3.83E-02	× 2.73E-02	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )
Carbon tetrachloride	1.57E-05	= ( 1.07E-02	× 5.25E-02	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )
Methylene chloride	2.24E-07	= ( 4.86E-03	× 1.65E-03	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )
Trichloroethylene	3.53E-05	= ( 3.16E-03	× 4.00E-01	× 1	× 8	× 250	× 25 )	÷ ( 70	× 25,550 )

**Notes:**

Inh - Risk – Inhalation Risk  
 Cair – Air Concentration  
 SFi – Inhalation Slope Factor  
 IR – Inhalation Rate  
 ET – Exposure Time  
 EF – Exposure frequency

ED – Exposure duration  
 BW – Body Weight  
 ATc – Averaging Time for Carcinogens  
 NV – No toxicity value available for this pathway.  
 NA – Not Applicable

**Attachment D**

**Table 27b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Industrial Worker: Inhalation of Chemicals in Indoor Air Pathway – Carcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Cair} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED})}{(\text{BW} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= (	Cair mg/m³	×	IR m³/day	×	ET hours/day	×	EF days/year	×	ED year	) ) ÷ (	BW kg	×	ATn days	×	RfDi mg/kg-day	)	
1,2,4-Trimethylbenzene	1.77E+00	= (	3.88E-02	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	1.71E-03	)
1,3,5-Trimethylbenzene	4.27E-01	= (	9.32E-03	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	1.71E-03	)
1,4-Dichlorobenzene	3.29E-01	= (	9.62E-01	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	2.29E-01	)
Benzene	3.50E-01	= (	3.83E-02	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	8.57E-03	)
Carbon tetrachloride	NA	= (	1.07E-02	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	NV	)
Methylene chloride	4.44E-04	= (	4.86E-03	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	8.57E-01	)
Trichloroethylene	2.17E-02	= (	3.16E-03	×	1	×	8	×	250	×	25	)	÷ (	70	×	9,125	×	1.14E-02	)

**Notes:**

Inh - Risk – Inhalation Hazard Quotient

Cair – Air Concentration

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

BW – Body Weight

ATn – Averaging Time for Noncarcinogens

RfDi – Inhalation Reference Dose

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 28a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Maintenance Worker: Incidental Ingestion of Soil Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(C_{\text{soil}} \times SF_{\text{o}} \times CF \times EF \times ED \times SIR \times FI)}{(BW \times ATc)}$$

Equation Units	Ing - Risk unitless	=	(	C <sub>soil</sub> mg/kg	×	SF <sub>o</sub> kg-day/mg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	)	÷	(	BW kg	×	ATc days	)
Arsenic	1.15E-07	=	(	4.99E+00	×	1.50E+00	×	1E-06	×	22	×	25	×	100	×	0.5	)	÷	(	70	×	25,550	)
Lead	NA	=	(	9.51E+01	×	a	×	1E-06	×	22	×	25	×	100	×	0.5	)	÷	(	70	×	25,550	)
Benzo(a)anthracene	3.17E-08	=	(	2.83E+00	×	7.30E-01	×	1E-06	×	22	×	25	×	100	×	0.5	)	÷	(	70	×	25,550	)
Benzo(a)pyrene	6.37E-07	=	(	5.68E+00	×	7.30E+00	×	1E-06	×	22	×	25	×	100	×	0.5	)	÷	(	70	×	25,550	)
Benzo(b)fluoranthene	5.89E-08	=	(	5.25E+00	×	7.30E-01	×	1E-06	×	22	×	25	×	100	×	0.5	)	÷	(	70	×	25,550	)
Indeno(1,2,3-cd)pyrene	4.06E-08	=	(	3.62E+00	×	7.30E-01	×	1E-06	×	22	×	25	×	100	×	0.5	)	÷	(	70	×	25,550	)

Notes:

Ing - Risk – Ingestion risk

SIR – Soil Ingestion Rate

C<sub>soil</sub> – Soil Concentration

FI – Fraction Ingested from Contaminated Source

SF<sub>o</sub> – Oral Slope Factor

BW – Body Weight

CF – Unit Conversion Factor

ATc – Averaging Time for Carcinogens

EF – Exposure Frequency

NV – No toxicity value available for this pathway.

ED – Exposure Duration

NA – Not Applicable

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

## Attachment D

**Table 28b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Maintenance Worker: Incidental Ingestion of Soil Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Csoil mg/kg	×	CF kg/mg	×	EF days/year	×	ED years	×	SIR mg/day	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day	)
Arsenic	7.2E-04	= (	4.99E+00	×	1E-06	×	22	×	25	×	100	×	0.5	) ÷ (	70	×	9,125	×	3.0E-04	)
Lead	NA	= (	9.51E+01	×	1E-06	×	22	×	25	×	100	×	0.5	) ÷ (	70	×	9,125	×	a	)
Benzo(a)anthracene	NA	= (	2.83E+00	×	1E-06	×	22	×	25	×	100	×	0.5	) ÷ (	70	×	9,125	×	NV	)
Benzo(a)pyrene	NA	= (	5.68E+00	×	1E-06	×	22	×	25	×	100	×	0.5	) ÷ (	70	×	9,125	×	NV	)
Benzo(b)fluoranthene	NA	= (	5.25E+00	×	1E-06	×	22	×	25	×	100	×	0.5	) ÷ (	70	×	9,125	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	3.62E+00	×	1E-06	×	22	×	25	×	100	×	0.5	) ÷ (	70	×	9,125	×	NV	)

**Notes:**

Ing - HQ – Ingestion Hazard

FI – Fraction Ingested from Contaminated Source

Csoil – Soil Concentration

BW – Body Weight

CF – Unit Conversion Factor

ATn – Averaging Time for Noncarcinogens

EF – Exposure Frequency

RfDo – Oral reference dose

ED – Exposure Duration

NV – No toxicity value available for this pathway.

SIR – Soil Ingestion Rate

NA – Not Applicable

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

## Attachment D

**Table 29a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Maintenance Worker: Incidental Dermal Contact with Soil Pathway – Carcinogenic Effects**

$$\text{Derm - Risk} = \frac{(C_{\text{soil}} \times SF_{\text{abs}} \times CF \times EF \times ED \times EV \times SA \times SSAF \times ABSd)}{(BW \times ATc)}$$

Equation Units	Derm - Risk unitless	$C_{\text{soil}}$ mg/kg	$SF_{\text{abs}}$ kg-day/mg	$CF$ kg/mg	$EF$ days/year	$ED$ years	$EV$ events/day	$SA$ cm <sup>2</sup>	$SSAF$ mg/cm <sup>2</sup> -event	$ABSd$ unitless	$) \div ($	$BW$ kg	$ATc$ days
Arsenic	2.40E-08	= ( 4.99E+00 × 1.58E+00 × 1E-06 × 22 × 25 × 1 × 3,300 × 0.1 × 3.00E-02 ) ÷ ( 70 × 25,550 )											
Lead	NA	= ( 9.51E+01 × a × 1E-06 × 22 × 25 × 1 × 3,300 × 0.1 × NA ) ÷ ( 70 × 25,550 )											
Benzo(a)anthracene	2.72E-08	= ( 2.83E+00 × 7.30E-01 × 1E-06 × 22 × 25 × 1 × 3,300 × 0.1 × 1.30E-01 ) ÷ ( 70 × 25,550 )											
Benzo(a)pyrene	5.47E-07	= ( 5.68E+00 × 7.30E+00 × 1E-06 × 22 × 25 × 1 × 3,300 × 0.1 × 1.30E-01 ) ÷ ( 70 × 25,550 )											
Benzo(b)fluoranthene	5.05E-08	= ( 5.25E+00 × 7.30E-01 × 1E-06 × 22 × 25 × 1 × 3,300 × 0.1 × 1.30E-01 ) ÷ ( 70 × 25,550 )											
Indeno(1,2,3-cd)pyrene	3.48E-08	= ( 3.62E+00 × 7.30E-01 × 1E-06 × 22 × 25 × 1 × 3,300 × 0.1 × 1.30E-01 ) ÷ ( 70 × 25,550 )											

**Notes:**

Derm - Risk – Dermal Risk

$C_{\text{soil}}$  – Soil Concentration

$SF_{\text{abs}}$  – Absorbed slope factor ( $SF_{\text{o}} \div ABS_{\text{gi}}$ )

$CF$  – Conversion factor

$EF$  – Exposure Frequency

$ED$  – Exposure Duration

$EV$  – Event Frequency

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

SA – Skin Surface Area

SSAF – Soil-to-skin Adherence Factor

$ABSd$  – Dermal Soil Absorption Factor

$BW$  – Body Weight

$ATc$  – Averaging Time for Carcinogens

NA – Not Applicable

NV – No toxicity value available for this pathway.

**Attachment D**

**Table 29b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Maintenance Worker: Incidental Dermal Contact with Soil Pathway – Noncarcinogenic Effects**

$$\text{Derm - HQ} = \frac{(\text{Csoil} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{EV} \times \text{SA} \times \text{SSAF} \times \text{ABSd})}{(\text{BW} \times \text{ATn} \times \text{RfDabs})}$$

Equation Units	Derm - HQ	=	(	Csoil	$\times$	CF	$\times$	EF	$\times$	ED	$\times$	EV	$\times$	SA	$\times$	SSAF	$\times$	ABSd	)	$\div$	(	BW	$\times$	ATn	$\times$	RfDabs	)
		unitless		mg/kg		kg/mg		days/year		years		events/day		cm <sup>2</sup>		mg/cm <sup>2</sup> -event		unitless			kg		days		mg/kg-day		
Arsenic	1.49E-04	=	(	4.99E+00	$\times$	1E-06	$\times$	22	$\times$	25	$\times$	1	$\times$	3,300	$\times$	0.1	$\times$	3.00E-02	)	$\div$	(	70	$\times$	9,125	$\times$	2.85E-04	)
Lead	NA	=	(	9.51E+01	$\times$	1E-06	$\times$	22	$\times$	25	$\times$	1	$\times$	3,300	$\times$	0.1	$\times$	NA	)	$\div$	(	70	$\times$	9,125	$\times$	a	)
Benzo(a)anthracene	NA	=	(	2.83E+00	$\times$	1E-06	$\times$	22	$\times$	25	$\times$	1	$\times$	3,300	$\times$	0.1	$\times$	1.30E-01	)	$\div$	(	70	$\times$	9,125	$\times$	NV	)
Benzo(a)pyrene	NA	=	(	5.68E+00	$\times$	1E-06	$\times$	22	$\times$	25	$\times$	1	$\times$	3,300	$\times$	0.1	$\times$	1.30E-01	)	$\div$	(	70	$\times$	9,125	$\times$	NV	)
Benzo(b)fluoranthene	NA	=	(	5.25E+00	$\times$	1E-06	$\times$	22	$\times$	25	$\times$	1	$\times$	3,300	$\times$	0.1	$\times$	1.30E-01	)	$\div$	(	70	$\times$	9,125	$\times$	NV	)
Indeno(1,2,3-cd)pyrene	NA	=	(	3.62E+00	$\times$	1E-06	$\times$	22	$\times$	25	$\times$	1	$\times$	3,300	$\times$	0.1	$\times$	1.30E-01	)	$\div$	(	70	$\times$	9,125	$\times$	NV	)

**Notes:**

Derm - HQ – Dermal Hazard Quotient

ABSd – Dermal Soil Absorption Factor

Csoil – Soil Concentration

BW – Body Weight

CF – Conversion factor

ATn – Averaging Time for noncarcinogens

EF – Exposure Frequency

RfDabs – Absorbed reference dose (RfDo  $\times$  ABSgi)

ED – Exposure Duration

NA – Not Applicable

EV – Event Frequency

NV – No toxicity value available for this pathway.

SA – Skin Surface Area

SSAF – Soil-to-skin Adherence Factor

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

## Attachment D

**Table 30a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Maintenance Worker: Incidental Inhalation of Soil (Fugitive Emissions and Volatile Compounds) Pathway– Carcinogenic Effects**

$$\text{Inh - Risk} = \frac{(\text{Csoil} \times \text{SFi} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times [(1/\text{VF}) + (1/\text{PEF})])}{(\text{BW} \times \text{ATc})}$$

Equation Units	Inh - Risk unitless	= (	Csoil mg/kg	×	SFi kg-day/mg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 / VF m³/kg ]	+ 1 / PEF m³/kg ] )	÷ (	BW kg	×	ATc days
Arsenic	6.98E-11	= (	4.99E+00	×	1.51E+01	×	1.5	×	8	×	22	×	25	×	[ 1 / NA ]	+ 1 / 3.97E+09 ] )	÷ (	70	×	25,550 )
Lead	NA	= (	9.51E+01	×	a	×	1.5	×	8	×	22	×	25	×	[ 1 / NA ]	+ 1 / 3.97E+09 ] )	÷ (	70	×	25,550 )
Benzo(a)anthracene	NA	= (	2.83E+00	×	NV	×	1.5	×	8	×	22	×	25	×	[ 1 / NC ]	+ 1 / 3.97E+09 ] )	÷ (	70	×	25,550 )
Benzo(a)pyrene	1.63E-11	= (	5.68E+00	×	3.08E+00	×	1.5	×	8	×	22	×	25	×	[ 1 / NC ]	+ 1 / 3.97E+09 ] )	÷ (	70	×	25,550 )
Benzo(b)fluoranthene	NA	= (	5.25E+00	×	NV	×	1.5	×	8	×	22	×	25	×	[ 1 / NC ]	+ 1 / 3.97E+09 ] )	÷ (	70	×	25,550 )
Indeno(1,2,3-cd)pyrene	NA	= (	3.62E+00	×	NV	×	1.5	×	8	×	22	×	25	×	[ 1 / NC ]	+ 1 / 3.97E+09 ] )	÷ (	70	×	25,550 )

**Notes:**

Inh - Risk – Inhalation Risk

Csoil – Soil Concentration

SFi – Inhalation Slope Factor

IR – Inhalation Rate

ET – Exposure Time

EF – Exposure frequency

ED – Exposure duration

a – Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

VF – Volatilization Factor

PEF – Particulate Emission Factor

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

NC – Not Calculated

## Attachment D

**Table 30b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Maintenance Worker: Incidental Inhalation of Soil (Fugitive Emissions and Volatile Compounds) Pathway – Carcinogenic Effects**

$$\text{Inh - HQ} = \frac{(\text{Csoil} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times ([1/\text{VF}] + [1/\text{PEF}]))}{(\text{BW} \times \text{ATn} \times \text{RfDi})}$$

Equation Units	Inh - HQ unitless	= (	Csoil mg/kg	×	IR m³/hour	×	ET hours/day	×	EF days/year	×	ED year	×	[ 1 /	VF m³/kg	+ 1 /	PEF m³/kg	] ÷ (	BW kg	×	ATn days	×	RfDi mg/kg-day	)
Arsenic	NA	= (	4.99E+00	×	1.5	×	8	×	22	×	25	×	[ 1 /	NA	+ 1 /	3.97E+09	] ÷ (	70	×	9,125	×	NV	)
Lead	NA	= (	9.51E+01	×	1.5	×	8	×	22	×	25	×	[ 1 /	NA	+ 1 /	3.97E+09	] ÷ (	70	×	9,125	×	a	)
Benzo(a)anthracene	NA	= (	2.83E+00	×	1.5	×	8	×	22	×	25	×	[ 1 /	NC	+ 1 /	3.97E+09	] ÷ (	70	×	9,125	×	NV	)
Benzo(a)pyrene	NA	= (	5.68E+00	×	1.5	×	8	×	22	×	25	×	[ 1 /	NC	+ 1 /	3.97E+09	] ÷ (	70	×	9,125	×	NV	)
Benzo(b)fluoranthene	NA	= (	5.25E+00	×	1.5	×	8	×	22	×	25	×	[ 1 /	NC	+ 1 /	3.97E+09	] ÷ (	70	×	9,125	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	3.62E+00	×	1.5	×	8	×	22	×	25	×	[ 1 /	NC	+ 1 /	3.97E+09	] ÷ (	70	×	9,125	×	NV	)

**Notes:**

Inh - Risk - Inhalation Hazard Quotient

PEF - Particulate Emission Factor

Csoil - Soil Concentration

BW - Body Weight

IR - Inhalation Rate

ATn - Averaging Time for Noncarcinogens

ET - Exposure Time

RfDi - Inhalation Reference Dose

EF - Exposure frequency

NV - No toxicity value available for this pathway.

ED - Exposure duration

NA - Not Applicable

VF - Volatilization Factor

NC - Not Calculated

a - Quantifying risk following exposure involves many uncertainties, some of which may be unique to lead.

Toxicity criteria for lead have not been derived by USEPA.

## Attachment D

**Table 30c**  
**Maintenance Worker: Volatilization Factor Calculations**

Equation:

$$VF = \frac{Q}{C_{VF}} \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4} \frac{m^2}{cm^3}$$

Chemical	Q/C <sub>VF</sub> (g/m <sup>2</sup> -s)/(kg/m <sup>3</sup> )	π	D <sub>A</sub> (cm <sup>2</sup> /s)	T (s)	2	ρ <sub>b</sub> (g/cm <sup>3</sup> )	10 <sup>-4</sup> (m <sup>2</sup> /cm <sup>3</sup> )	VF (m <sup>3</sup> /kg)
Benzo(a)anthracene	73.32	3.14	NC	7.88E+08	2	1.38	1.00E-04	NC
Benzo(a)pyrene	73.32	3.14	NC	7.88E+08	2	1.38	1.00E-04	NC
Benzo(b)fluoranthene	73.32	3.14	NC	7.88E+08	2	1.38	1.00E-04	NC
Indeno(1,2,3-cd)pyrene	73.32	3.14	NC	7.88E+08	2	1.38	1.00E-04	NC

Notes:

Default values are as presented in Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002).

VF – Volatilization Factor (m<sup>3</sup>/kg) (calculated)

Q/C<sub>VF</sub> – Inverse of mean concentration at the center of 1 acre square source  
(g/m<sup>2</sup>-s)/(kg/m<sup>3</sup>)(Value used is for Minneapolis, MN.)

π – pi (3.14)

D<sub>A</sub> – Apparent Diffusivity (cm<sup>2</sup>/s)

T – Exposure interval (s)

ρ<sub>b</sub> – Dry soil bulk density (g/cm<sup>3</sup>) (site-specific value)

NC – Not calculated

## Attachment D

**Table 30d**  
**Maintenance Worker: Apparent Diffusivity Calculations**

Equation:

$$D_A = \frac{(\theta_a^{3.33} \times D_i \times H') + (\theta_w^{3.33} \times D_w)}{\eta^2} \times \frac{1}{(\rho_b \times K_d) + \theta_w + (\theta_a \times H')}$$

Chemical Units	VOC?	$\theta_a$ (Lair / Lsoil )	$D_i$ (cm <sup>2</sup> /s)	$H'$ unitless	$\theta_w$ (Lwater / Lsoil )	$D_w$ (cm <sup>2</sup> /s)	$\eta$ (Lpore / Lsoil )	$\rho_b$ (g/cm <sup>3</sup> )	$\rho_s$ (g/cm <sup>3</sup> )	$K_d$ (cm <sup>3</sup> /g )	$D_A$ (cm <sup>2</sup> /s)
Benzo(a)anthracene	No	3.29E-01	5.10E-02	4.91E-04	0.15	9.00E-06	4.79E-01	1.38	2.65	1.39E+03	NC
Benzo(a)pyrene	No	3.29E-01	4.30E-02	4.63E-05	0.15	9.00E-06	4.79E-01	1.38	2.65	4.72E+03	NC
Benzo(b)fluoranthene	No	3.29E-01	2.26E-02	2.69E-05	0.15	5.56E-06	4.79E-01	1.38	2.65	4.82E+03	NC
Indeno(1,2,3-cd)pyrene	No	3.29E-01	1.90E-02	1.42E-05	0.15	5.66E-06	4.79E-01	1.38	2.65	1.61E+04	NC

Notes:

$D_A$  – apparent diffusivity

$\theta_a$  – air-filled soil porosity

$D_i$  – diffusivity in air

$H'$  – dimensionless Henry's Law constant

$\theta_w$  – water-filled soil porosity

$D_w$  – diffusivity in water

$\eta$  – total soil porosity

$\rho_b$  – dry soil bulk density based on soil type of silty clay. Value obtained from *User'S Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA, 2003).

$\rho_s$  – soil particle density

$K_d$  – soil-water partition coefficient, where:

$$K_d = K_{oc} \times f_{oc}$$

$K_{oc}$  – soil organic carbon partition coefficient (cm<sup>3</sup> /g)

$f_{oc}$  – fraction organic carbon in soil (g/g) (A default value of 0.006 g/g was used.)

## Attachment D

**Table 30e**  
**Calculation of Blood Lead Concentrations (PbBs) for Non-residential Receptors (Maintenance Workers)**

Exposure Variable	PbB Equation <sup>1</sup>		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
	1*	2**			Using Equation 1		Using Equation 2	
					GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het	GSD <sub>i</sub> = Hom	GSD <sub>i</sub> = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	99.31	99.31	99.31	99.31
R <sub>fetal/maternal</sub>	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD <sub>i</sub>	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3
PbB <sub>0</sub>	X	X	Baseline PbB	ug/dL	1.5	1.7	1.5	1.7
IR <sub>S</sub>	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR <sub>S+D</sub>		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W <sub>S</sub>		X	Weighting factor; fraction of IR <sub>S+D</sub> ingested as outdoor soil	--	--	--	1.0	1.0
K <sub>SD</sub>		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
AF <sub>S, D</sub>	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
EF <sub>S, D</sub>	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
AT <sub>S, D</sub>	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB <sub>adult</sub>	PbB of adult worker, geometric mean		ug/dL	1.6	1.8	1.6	1.8	
PbB <sub>fetal, 0.95</sub>	95th percentile PbB among fetuses of adult workers		ug/dL	5.0	6.5	5.0	6.5	
PbB <sub>t</sub>	Target PbB level of concern (e.g., 10 ug/dL)		ug/dL	10.0	10.0	10.0	10.0	
P(PbB <sub>fetal</sub> > PbB <sub>t</sub> )	Probability that fetal PbB > PbB <sub>t</sub> , assuming lognormal distribution		%	0.5%	1.6%	0.5%	1.6%	

<sup>1</sup> Equation 1 does not apportion exposure between soil and dust ingestion (excludes W<sub>S</sub>, K<sub>SD</sub>).

When IR<sub>S</sub> = IR<sub>S+D</sub> and W<sub>S</sub> = 1.0, the equations yield the same PbB<sub>fetal, 0.95</sub>.

\*Equation 1, based on Eq. 1, 2 in USEPA (1996).

$PbB_{adult} = (PbS * BKSF * IR_{S+D} * AF_{S,D} * EF_S / AT_{S,D}) + PbB_0$
$PbB_{fetal, 0.95} = PbB_{adult} * (GSD_i^{1.645} * R)$

\*\*Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).

$PbB_{adult} = PbS * BKSF * [(IR_{S+D}) * AF_S * EF_S * W_S] + [K_{SD} * (IR_{S+D}) * (1 - W_S) * AF_D * EF_D] / 365 + PbB_0$
$PbB_{fetal, 0.95} = PbB_{adult} * (GSD_i^{1.645} * R)$

## Attachment D

**Table 31a**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Subsistence Fisher – Adult: Ingestion of Fish Pathway – Carcinogenic Effects**

$$\text{Ing-Risk} = \frac{(\text{Cfish} \times \text{SFo} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{FIR} \times \text{FI})}{(\text{BW} \times \text{ATc})}$$

Equation Units	Ing - Risk unitless	= (	Cfish mg/kg	×	SFo kg-day/mg	×	EF events/year	×	ED years	×	FIR kg/event	×	FI unitless	) ÷ (	BW kg	×	ATc days
<b>Shorthead Redhorse and Walleye</b>																	
1-Methylnaphthalene	NA	= (	6.200E-01	×	NV	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )
<b>Smelt</b>																	
Benzo(a)anthracene	5.90E-05	= (	1.70E-01	×	7.30E-01	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )
Benzo(a)pyrene	5.21E-05	= (	1.50E-02	×	7.30E+00	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )
Benzo(b)fluoranthene	6.60E-06	= (	1.90E-02	×	7.30E-01	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )
Benzo(e)pyrene	NA	= (	9.80E-03	×	NV	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )
Dibenzo(a,h)anthracene	9.03E-06	= (	2.60E-03	×	7.30E+00	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )
Indeno(1,2,3-cd)pyrene	2.64E-06	= (	7.60E-03	×	7.30E-01	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	25,550 )

**Notes:**

Ing - Risk – Ingestion risk

Cfish – Concentration in fish

SFo – Oral Slope Factor

EF – Exposure Frequency

ED – Exposure Duration

FIR – Fish Ingestion Rate

FI – Fraction Ingested from Contaminated Source

BW – Body Weight

ATc – Averaging Time for Carcinogens

NV – No toxicity value available for this pathway.

NA – Not Applicable

## Attachment D

**Table 31b**  
**Risk Calculations: Reasonable Maximum Exposure**  
**Subsistence Fisher – Adult: Ingestion of Fish Pathway – Noncarcinogenic Effects**

$$\text{Ing - HQ} = \frac{(\text{Cfish} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{FIR} \times \text{FI})}{(\text{BW} \times \text{ATn} \times \text{RfDo})}$$

Equation Units	Ing - HQ unitless	= (	Cfish mg/kg	×	EF events/year	×	ED years	×	FIR kg/event	×	FI unitless	) ÷ (	BW kg	×	ATn days	×	RfDo mg/kg-day	)
<b>Shorthead Redhorse &amp; Walleye</b>																		
1-Methylnaphthalene	9.8E-03	= (	6.20E-01	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	7.0E-02	)
<b>Smelt</b>																		
Benzo(a)anthracene	NA	= (	1.70E-01	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(a)pyrene	NA	= (	1.50E-02	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(b)fluoranthene	NA	= (	1.90E-02	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	NV	)
Benzo(e)pyrene	NA	= (	9.80E-03	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	NV	)
Dibenzo(a,h)anthracene	NA	= (	2.60E-03	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	NV	)
Indeno(1,2,3-cd)pyrene	NA	= (	7.60E-03	×	350	×	30	×	0.081	×	1	) ÷ (	70	×	10,950	×	NV	)

**Notes:**

Ing - HQ – Ingestion Hazard  
 Cfish – Concentration in fish  
 EF – Exposure Frequency  
 ED – Exposure Duration  
 FIR – Fish Ingestion Rate  
 FI – Fraction Ingested from Contaminated Source

BW – Body Weight  
 ATn – Averaging Time for Noncarcinogens  
 RfDo – Oral reference dose  
 NV – No toxicity value available for this pathway.  
 NA – Not Applicable